Antennas for Emcomm

Communications Academy 2011

Brian Daly, WB7OML

Definition of an antenna

- Webster:
    - “a usually metallic device (as a rod or wire) for radiating or receiving radio waves”
- IEEE
    - “a means for radiating or receiving radio waves”
- Balanis (“Antenna Theory and Analysis”)
    - “transitional structure between free space and a guiding structure” (transmission line such as coax or waveguide)

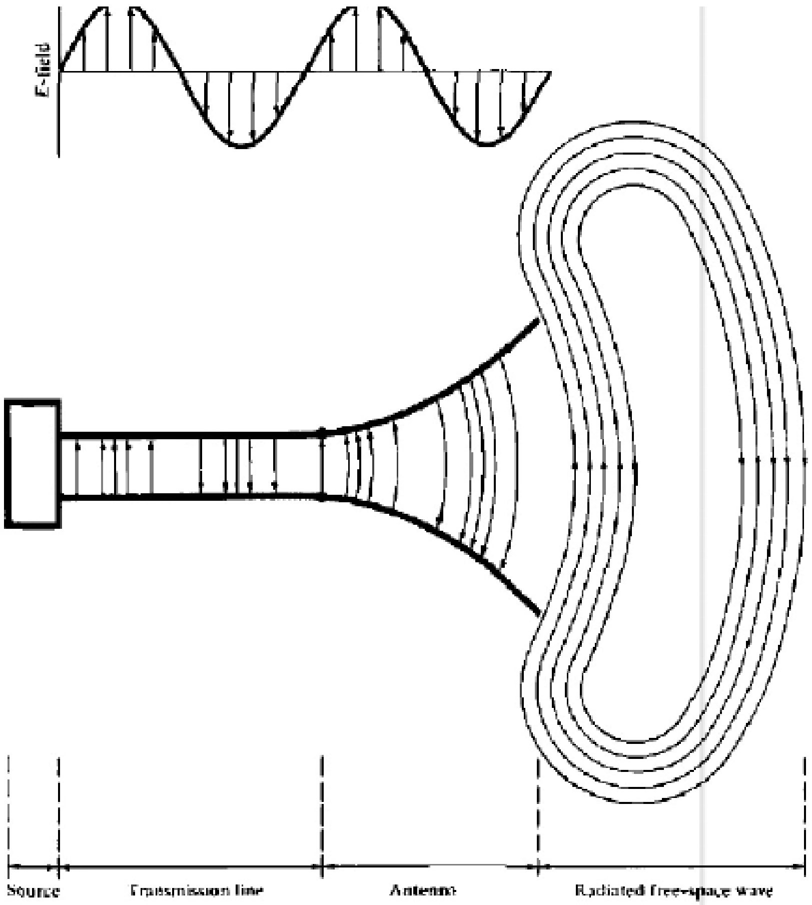
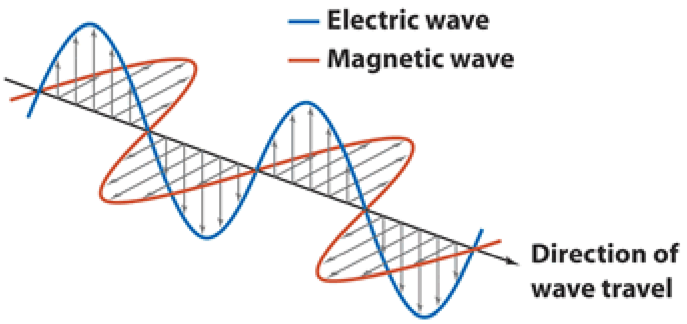


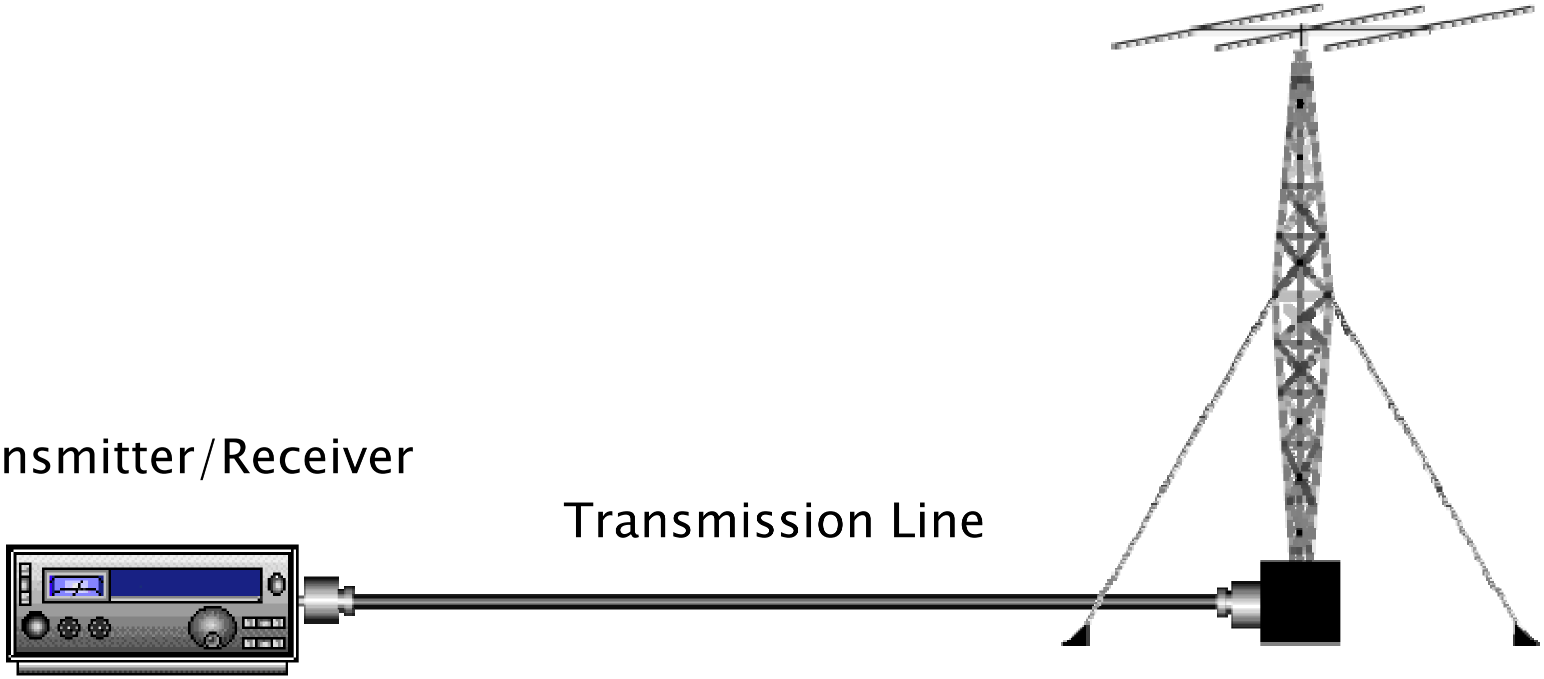
Figure 1.1 Antenna as a transition device.

How do we create "radiation"?

- Fundamental relation for electromagnetic radiation:
  - To create radiation, there must be a time-varying current or an acceleration (or deceleration) of charge
- Electromagnetic waves includes both an electric and a magnetic component



An Antenna System



Antenna

Transmitter/Receiver

Transmission Line

Transmit and Receive Antennas

- “Reciprocity Theorem”
  - An antenna that has certain design characteristics as a transmit antenna will have the identical characteristics as a receive antenna
  - Fundamental property → the receiving pattern of an antenna when used for receiving is identical to the far-field radiation pattern of the antenna when used for transmitting
  - Radiation patterns the antenna can be viewed as either transmitting or receiving, whichever is more convenient

$$\frac{P_{1r}}{P_{2t}} = \frac{P_{2r}}{P_{1t}}$$

- A transmit antenna exhibits the same characteristics operating as a receive antenna, and visa versa

- Parameters include gain, radiation pattern, impedance, bandwidth, resonant frequency and polarization

Basic Antenna Parameters

- An antenna is a piece of metal wire or tubing
  - Thus it cannot (and does not) amplify, generate signals on it own, or do anything else but “radiate” fields presented to it by the transmitter
- But doesn’t “gain” mean something like “make bigger” or “amplify”?
  - Not in the antenna definition!
  - Gain refers to an antenna’s ability to focus energy more in one direction than in another direction

Basic Antenna Parameters

- Radiation Intensity
  - Total power radiated from an antenna per unit solid angle
- Directivity (D)
  - Ratio of the radiation intensity in a given direction to the ratio averaged over all directions (or isotropic source)
- Antenna Radiation Efficiency (e_{cd})
  - Takes into account losses (conduction & dielectric)

$$P_{rad} = e_{cd} P_{in}$$

- Gain (G)
  - Ratio of the intensity in a given direction to the radiation intensity that would be obtained if the antenna radiated isotropically
  - Related to directivity through antenna radiation efficiency

$$G_0 = e_{cd} D_0$$

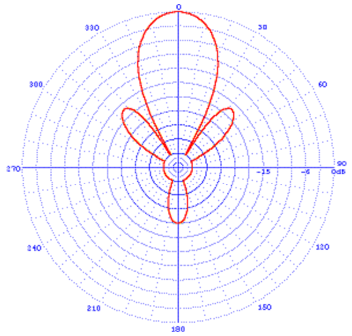
- Relative Gain
  - Ratio of the power gain in a given direction to the power gain of a reference antenna in its referenced direction
- Input Impedance
  - Impedance at the antenna terminals
  - Voltage applied at terminals / Current flowing at the terminals

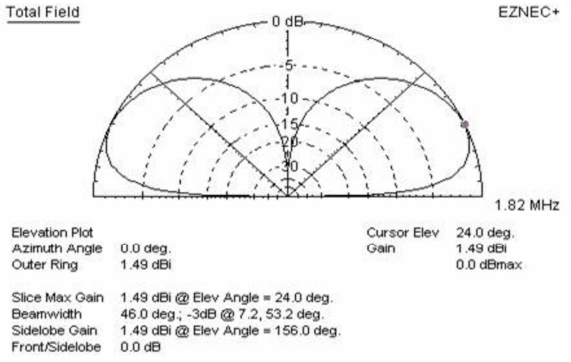
Antenna Categories

- Omnidirectional
  - May be “weakly directional antennas”
  - Receive or radiate more or less in all directions
    - all *horizontal* directions, typically with reduced performance in the direction of the sky or the ground (a true isotropic radiator is not possible to build)
  - Good for when the relative position of the other station is unknown or arbitrary
  - Also used at lower frequencies where a directional antenna would be too large, or simply to cut costs in applications where a directional antenna isn't required
- Directional or beam antennas
  - Intended to preferentially radiate or receive in a particular direction or directional pattern

Antenna Patterns

- Radiation pattern of an antenna
  - plot of the relative field strength of the radio waves emitted by the antenna at different angles
- Pattern types
  - E-plane → axis of antenna
  - H-plane → perpendicular to axis of antenna
- Azimuth Pattern
- Elevation Pattern





```
Elevation Plot                                  Cursor Elev   24.0 deg.
Azimuth Angle    0.0 deg.                       Gain          1.49 dBi
Outer Ring       1.49 dBi                                     0.0 dBmax

Slice Max Gain   1.49 dBi @ Elev Angle = 24.0 deg.
Beamwidth        46.0 deg.; -3dB @ 7.2, 53.2 deg.
Sidelobe Gain    1.49 dBi @ Elev Angle = 156.0 deg.
Front/Sidelobe   0.0 dB
```

Understanding dBi and dBd

- 0dB =“Unity Gain” or what goes in comes out the other end
- Negative gain (-dB) = “loss” or there is less at the output than the input
  - Power is half at -3db
- Positive gain (+dB) =“gain” or more power comes out the output than went in the input in the maximum direction of radiation
  - Power is double at +3db

“Gain” is referenced to either..

- An isotropic radiator (theoretical) → dbi
- A standard ½-wave dipole → dBd
- Antenna gain of 2.15 dBi = 0 dBd

Effective Radiated Power

- FCC definition
  - “Effective Radiated Power (e.r.p) (in a given direction) is the product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction.”
- Don’t forget Feedline losses
  - must be taken into account to determine the ‘power supplied to the antenna’ based on the power at the RF connector of the radio

Polarization

- Simply, which was do I orient the antenna?
  - Electric field component of the radiated wave
  - ½ wave dipole horizontally oriented → E-field is strongest parallel to the wire → horizontal polarization
- Ideally, the transmit and receive antennas are aligned exactly in the same orientation
- Misalignment, or worst case total opposite alignment → significant degradation in received signal
- Terrestrial LOS path →signal polarization tends to stay relatively constant
- Sky-wave propagation → usually changes the polarization
- Cross polarization reduces reception by as much as 30 db

Antenna Polarization—What Does it Mean and When is it Important?
Joel R. Hallas, W1ZR; QST, July 201, pp. 55-56

Basic Design Questions

- Who do I want to talk to?
- On what frequencies?
- Where will I be located?
- Where are they located?
- What type of antenna are they using?

Antenna Basics

- Rule #1
  - Any conductor can act as an antenna for radio signals

Antenna Basics

- Rule #2
  - Any conductor may not radiate efficiently
  - For an antenna to radiate and receive radio signals efficiently
    - Dimensions must be an appreciable fraction of the signal’s wavelength

- Rule #3
  - The most important point about V/UHF radios is that ANTENNA HEIGHT is more important than the output power of the device
    - A 4-watt handheld radio attached to an antenna on the roof of a vehicle can frequently communicate nearly as far as a 50-watt mobile transmitter connected to the same antenna
    - The more than 10 times additional power of the 50-watt unit rarely increases the communications range more than 20% or 30%.

Quiz

- Which of these materials can I use to make an antenna?

a) Metal wire
b) Metal rod
c) Water
d) Metal tube

Seawater Antenna

- Space and Naval Warfare Systems Command (SPAWAR) Systems Center Pacific has developed a technology that uses the magnetic induction properties of sodium chloride (salt) in sea water to create a VHF antenna
- Sea water is pumped from the ocean into a stream through a current probe (magnetic core) and the width and length of the stream determine the frequency capabilities
- An 80-foot-high stream could transmit and receive from 2 to 400 mHz with a relatively small footprint
- The Sea Water Antenna is capable of transmitting and receiving VHF signals and has been tested at a receiving range of over 30 miles

Daniel Tam, KE6FRY

http://www.public.navy.mil/spawar/Pacific/TechTransfer/ProductsServices/Pages/SeaWaterAntennaSystem.aspx
http://www.youtube.com/watch?v=9tIZUhu21sQ

Antennas for VHF/UHF

Fundamentals

How does RF behave at VHF/UHF?

- Line of sight
  - Let’s not worry about tropospheric ducting, sporadic E, meteor scatter, or other phenomena
- In building penetration (or lack thereof) highly dependent on frequency
- Signals bounce off things and used mobile in many cases
  - Multipath, fading, “picket fencing”
- Short range communications
  - Extended by repeaters with high antennas and more power
- Virtually all portable antennas compromise gain for small size and the convenience size affords the user

Antennas for VHF/UHF

HT Operation

Characteristics of HT Operation

- Ultimate in portability
- Low power
  - Milliwatts to maybe 5 watts
- Usually does not have the best antenna
- Used relatively close to the body
- Low duty cycle
- *Generally* not adequate as a primary radio for emergency communications
  - Excellent for public service event support, search & rescue

The “Rubber Duck”

- Compact design for short range communications
- Poor choice for anything beyond that
    - Almost anything works better
- National Institute of Standards tests at 2m
    - “Rubber duck" has -5db gain compared to a quarter wave antenna held at shoulder height
    - 5w HT with rubber duck antenna held at shoulder height would actually radiate 1.5 watts ERP
    - HT on your belt attenuates the signal another 20db, reducing ERP to only 15 milliwatts
- Possibly an option for:
    - Shelter communications
    - Neighborhood communications (CERT teams)
    - Public service short range communications

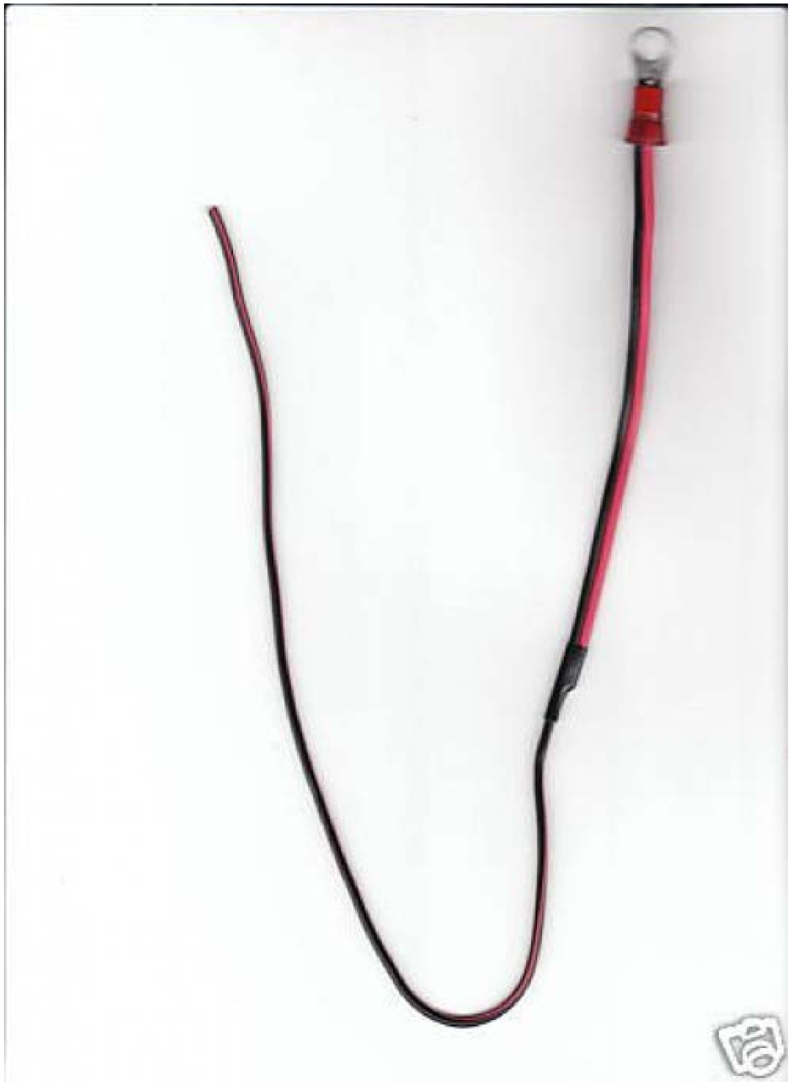
How can I improve the “rubber duck”?

- Add a *tiger tail*
- Quarter wavelength (19-1/4" for 2 meters) piece of #14 through #20 stranded wire, crimped and soldered to a battery clip
- Clamped to the outer collar of the connector on your HT antenna → help prevent RF from the HT from coupling with your body
- “Tiger tail" is directional and can be used to change both radiation angle and direction
  - Best simplex performance when pointed in the general direction of the station you are communicating with
  - In marginal conditions, extending the tiger tail horizontally, point your hand to steer the radiation pattern
  - Experiment with the angle of the tiger tail to get the best results

Note I intentionally did not call the tiger tail a counterpoise

The Tiger Tail

- Stranded insulated wire
  - 19.5" on 2m
  - 11.5" for 220
  - 6.5" for 440
- Crimped and soldered to a battery clip or use a small spring tension clip that will fit the BNC antenna connector with the wire attached to it
- Small lead fishing weight at the end of the wire will help to keep the wire vertical
- If the "rubber duck" antenna that came with the HT does not come off, then you will have to make the connection inside the HT to a grounded point



Flexible or Telescoping Antennas

- Larger size → work best when out in open, stationary
- Telescoping antennas → be careful extending and retracting
  - Wobbling or loose, maybe time for a new antenna
- Check connector often
- Flexible antennas
  - Safer than telescoping when working around others
  - Better choice for some applications
    - Dense vegetation in SAR operations

¼ Wave Antenna

- Better choice for HT operation
- Flexible or telescoping design
- ¼ wave at shoulder height with a *tiger tail* → "unity" gain
  - 5 db improvement over a rubber duck
- ¼ wave mag mount on an improvised ground plane → even better improvement

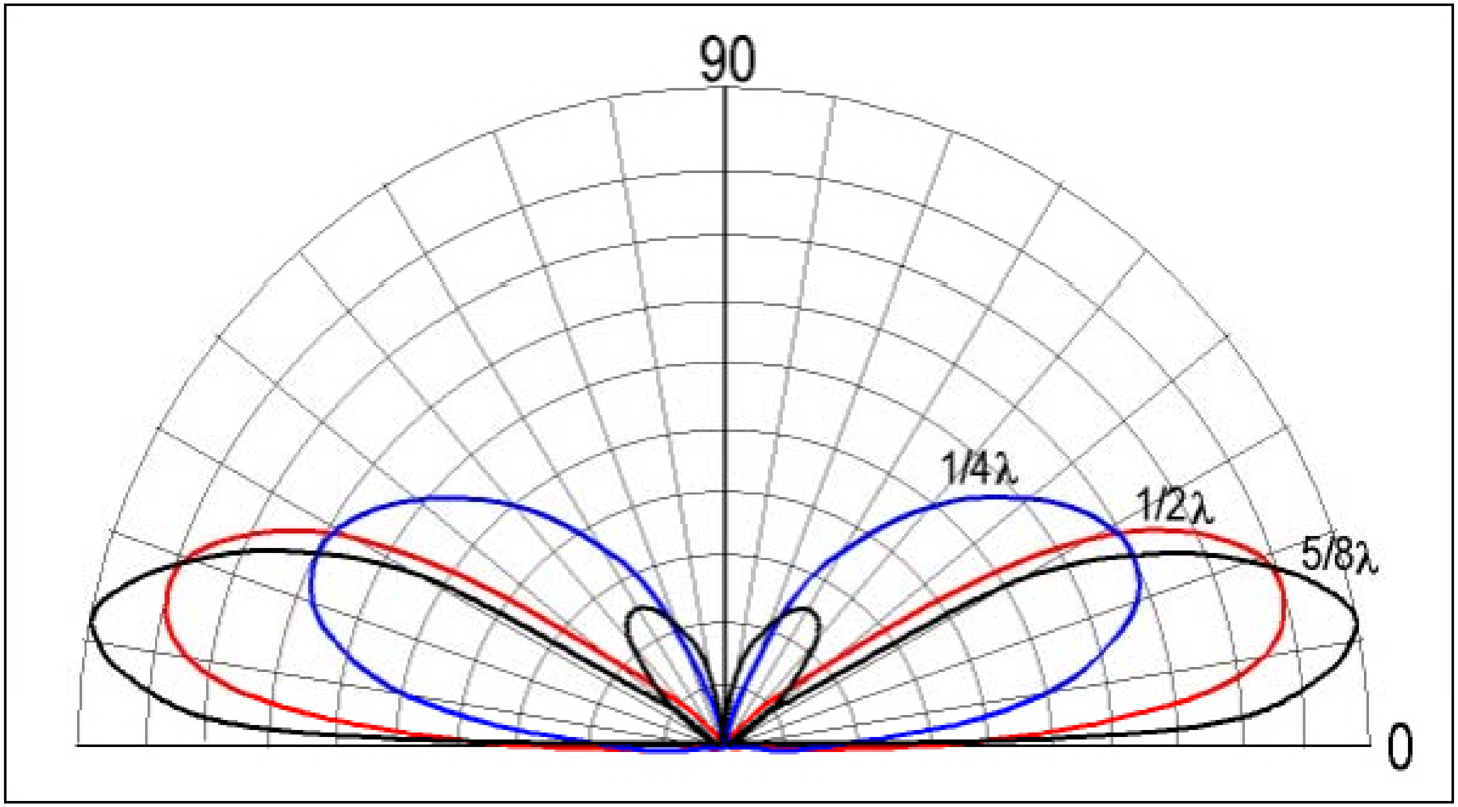
½ Wave Antenna

- Marginal signal locations → telescoping ½ wave is a good choice
  - ½ wave telescoping antenna with a "tiger tail" improves simplex communications even more
- ½ wave without a ground plane → same unity gain as a ¼ wave when used with a ground plane
- Adding an effective ground plane or counterpoise to a half- wave produces roughly 2 db of gain

5/8 Wave

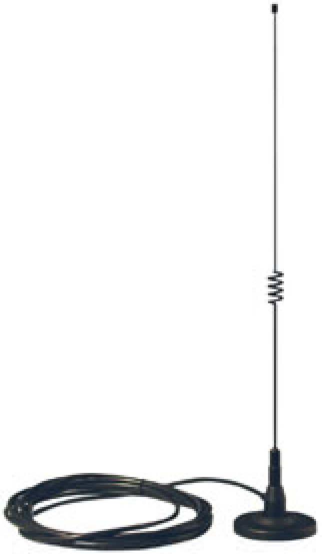
- 5/8th wave has about a 1.85dbd gain, which equates to about 4dbi
- Low angle of radiation
  - 16 degrees

Comparison of ¼, ½ and 5/8 wave antenna patterns



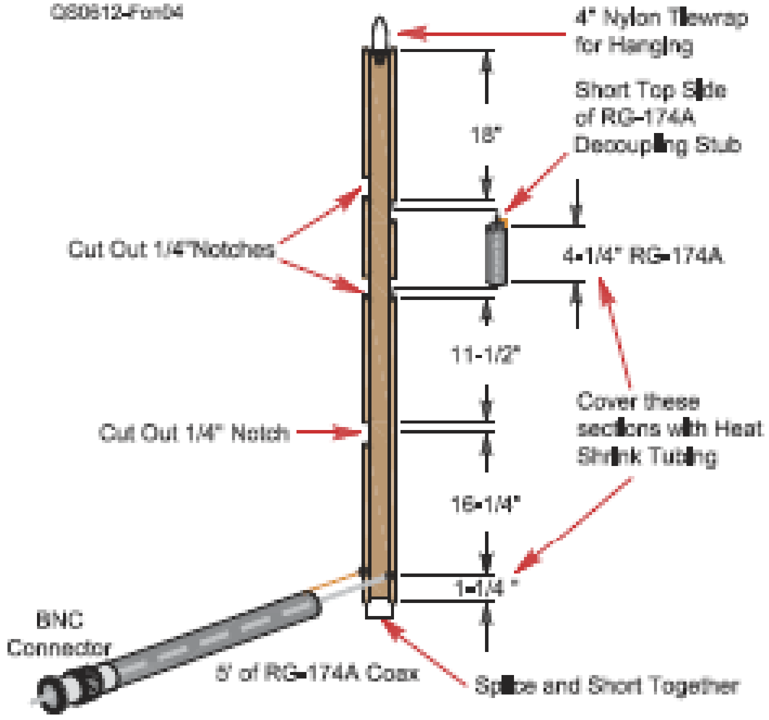
Portable Mag Mount Antenna

- If operating your HT from a stationary location, a ¼ or ½ wave mag mount antenna is a good choice
- Mag mount uses car as the ground plane, so need to improvise!
  - Can use any large metal object
  - Metal filing cabinet
  - Metal workbench
  - Refrigerator
  - Fence or Balcony railing
  - Aluminum foil over a large piece of cardboard



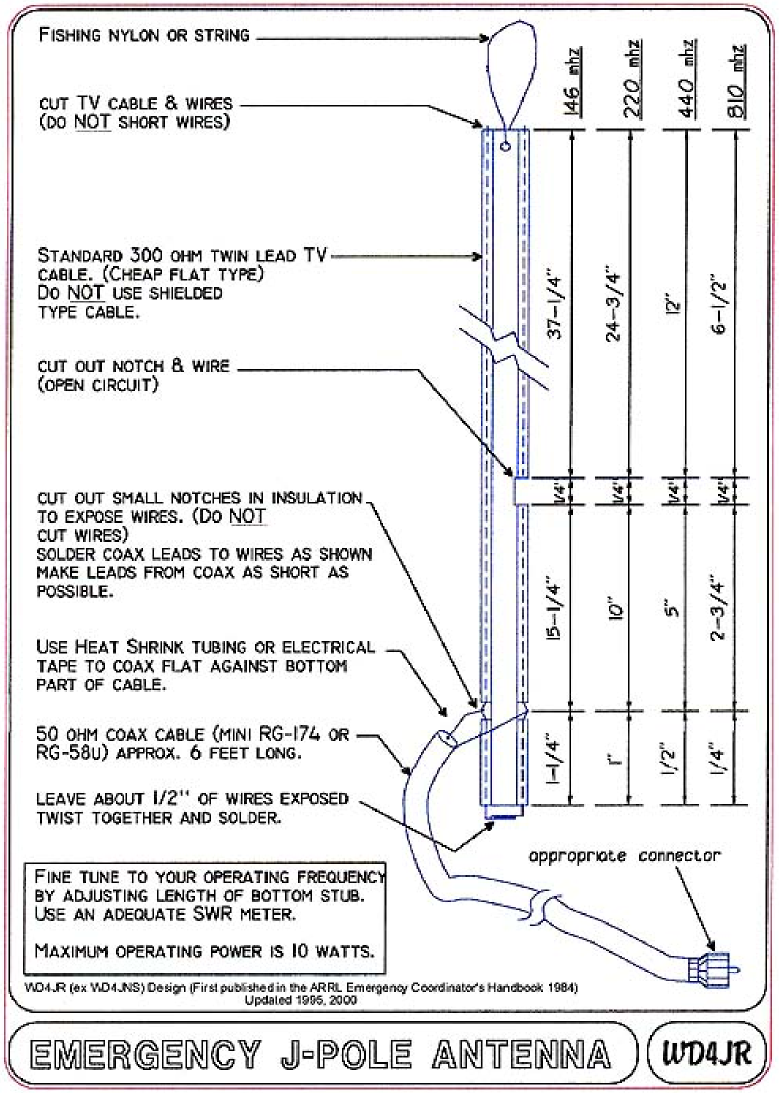
Roll-up J-Pole

- Good for stationary operation
- Made from 300 Ohm TV Twin-lead
- Several dB gain over a rubber duck
- Single or dual band designs


QS0612-Fon04
4" Nylon Tiewrap for Hanging
Short Top Side of RG-174A Decoupling Stub
18"
Cut Out 1/4"Notches
4-1/4" RG-174A
11-1/2"
Cover these sections with Heat Shrink Tubing
Cut Out 1/4" Notch
16-1/4"
1-1/4 "
BNC Connector
5' of RG-174A Coax
Splice and Short Together

The DBJ-2: A Portable VHF-UHF Roll-Up J-pole Antenna for Public Service
Edison Fong, WB6IQN; QST, March 2007

Emergency J-pole



FISHING NYLON OR STRING

CUT TV CABLE & WIRES
(DO NOT SHORT WIRES)

STANDARD 300 OHM TWIN LEAD TV CABLE. (CHEAP FLAT TYPE)
DO NOT USE SHIELDED TYPE CABLE.

CUT OUT NOTCH & WIRE
(OPEN CIRCUIT)

CUT OUT SMALL NOTCHES IN INSULATION TO EXPOSE WIRES. (DO NOT CUT WIRES)
SOLDER COAX LEADS TO WIRES AS SHOWN
MAKE LEADS FROM COAX AS SHORT AS POSSIBLE.

USE HEAT SHRINK TUBING OR ELECTRICAL TAPE TO COAX FLAT AGAINST BOTTOM PART OF CABLE.

50 OHM COAX CABLE (MINI RG-174 OR RG-58U) APPROX. 6 FEET LONG.

LEAVE ABOUT 1/2" OF WIRES EXPOSED
TWIST TOGETHER AND SOLDER.

appropriate connector

FINE TUNE TO YOUR OPERATING FREQUENCY BY ADJUSTING LENGTH OF BOTTOM STUB.
USE AN ADEQUATE SWR METER.

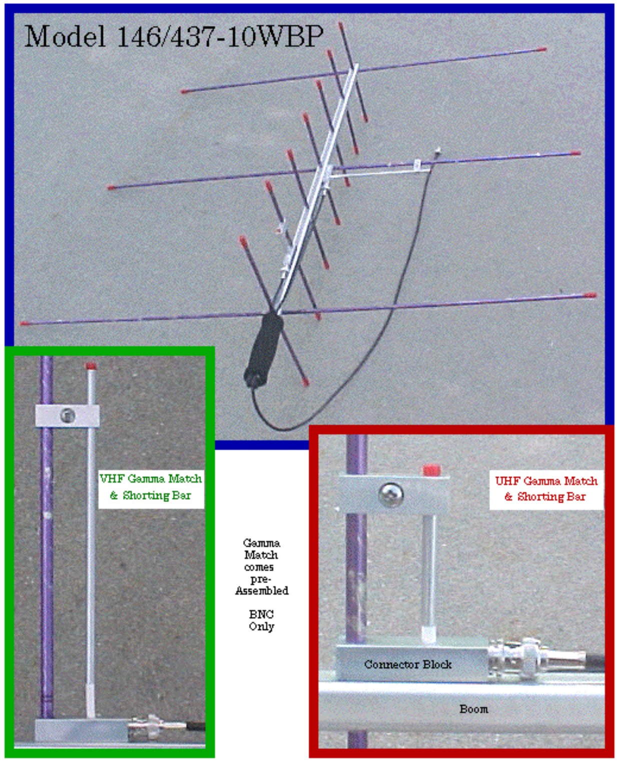
MAXIMUM OPERATING POWER IS 10 WATTS.

WD4JR (ex WD4JNS) Design (First published in the ARRL Emergency Coordinator's Handbook 1984)
Updated 1995, 2000

EMERGENCY J-POLE ANTENNA

WD4JR

Portable Yagi Antennas


Model 146/437-10WBP
VHF Gamma Match & Shorting Bar
UHF Gamma Match & Shorting Bar
Connector Block
Boom

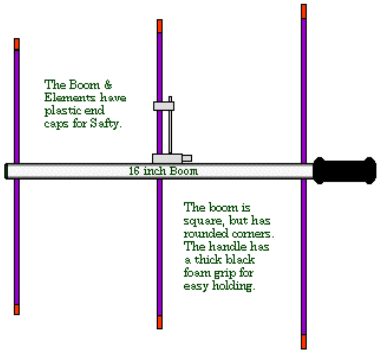
Gamma Match comes pre-Assembled

BNC Only

Arrow II Hand Held Portable

If Simple is Good, then this is Truly

Simply the Best


The Boom & Elements have plastic end caps for Safty.
16 inch Boom
The boom is square, but has rounded corners. The handle has a thick black foam grip for easy holding.

Assembly Instructions

Attach the elements to the boom, by screwing the elements together through the boom. Attach feed line to the BNC connector. That's it. The Antenna is pre-tuned and ready to go.

SPECIFICATIONS

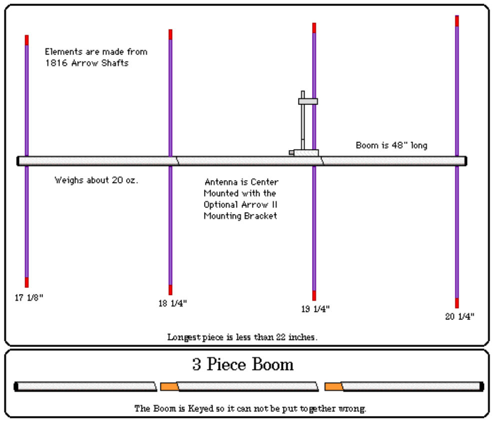
No. Elements 3
Element spacing is .2 wavelength.
SWR 1.2:1
Maximum Power (because the antenna is hand held power should be kept to <20 Watts)
Boom 3/4" Sq. (T6061 Aluminum)
Elements, Easton Aluminum Arrow Shafts
Gamma Match, Is attached to half of the driven element (comes pre-tuned).
Connector, BNC Only

Model 440-3

7 1/2 oz.

Only $ 29.00

Arrow II Back Pack Portable


Elements are made from 1816 Arrow Shafts
Boom is 48" long
Weighs about 20 oz.
Antenna is Center Mounted with the Optional Arrow II Mounting Bracket
17 1/8"
18 1/4"
19 1/4"
20 1/4"
Longest piece is less than 22 inches.
3 Piece Boom
The Boom is Keyed so it can not be put together wrong.

Model 146-4 II

Assembly Instructions

Assemble the boom, Attach the elements to the boom as shown above, by screwing the elements together through the boom. Attach feed line to the BNC connector. That's it. The Antenna is pre-tuned and ready to go.

If Simple is Good
then this is Truly
Simply the Best

Dual Band VHF/UHF Antennas

- Convenient for multiband HT radios
- But usually designed for one band and "acceptable" on the other
  - ¼ wave on 2 meters, 5/8 wave on 70 cm

Antennas for VHF/UHF

Mobile Operation

Did you know ….

- Size of vehicle has an impact on antenna performance?
  - Both pattern and gain
  - VHF Mobile Antenna Performance – The Other Half of the Story, Dan Richardson, K6MHE

- Placement of the antenna on the vehicle also has an impact

Where to mount?

- Roof of a vehicle is best place to mount a VHF/UHF antenna
  - Free from any vehicular obstruction
  - Roof also acts as a ground plane for the antenna
  - Centered is optimal
  - Ground plane size and shape in the immediate field

- Glass mounts → watch for embedded metal in the glass to block heat
  - "Soft-Ray", "EZE-Cool", "Solar-Coat", "Solar-Cool", "Insta-Clear" your glass is probably passivated and won't work with on-glass antennas

- Glass mount antennas → no ground plane under them
  - Return currents to flow on the outside of the coax
  - The coax does the majority of the radiation

- Want the whip/element to extend above the roof line of the vehicle
  - Prevent the car from blocking, distorting or shading the signal pattern of the antenna

Type of mount …

- Longest-lasting V/U mount is the NMO (new Motorola) series

- SO239 mounts, 5/16 inch Antenna Specialists stud mount, and snap-in 3/8 inch mount
  - Not waterproof, and may suffer from lack of sturdiness
- Mag mounts
  - Will scratch surface
  - How well they work depends on thickness of the metal

Larsen NMOHFGPS Mount

- Combines GPS antenna with the flexibility of adding virtually any Larsen NMO mount antenna from 27 MHz to 6.0 GHz

Some Common Issues

- If the chosen mount requires no holes, or uses set screws to hold it on, it will probably fail over time
- Lip mounts
  - Attach to trunk lids, hatches, or doors
  - Every time they're opened or shut, stress is put on both the antenna and mount
  - Don’t sand the paint or undercoating → rusting & failures!

Choosing a Mobile Antenna

- Urban areas
  - Want higher angles of radiation
  - Choose a lower gain antenna

- Suburban or rural areas
  - Higher gain antennas might be best
  - Depends on the HAAT (height above average terrain) of the repeater being used with respect to the mobile station's HAAT

Don’t fall into “Gain Game”

- Advertised gain is not the only consideration!

- If you don’t know what gain figures were measure against, they are not helpful!

Basic Antenna Types

- 1/4 Wave
  - A single radiating element approximately 1/4 wavelength long
  - Directivity 2.2 dBi, 0 dBd.

- Loaded 1/4 Wave
  - The loaded 1/4 wave antenna looks electrically like a 1/4 wave antenna but the loading allows the antenna to be physically smaller than a 1/4 wave antenna
  - Quite often this is implemented by placing a loading coil at the base of the antenna
  - Gain depends upon the amount of loading used
  - Directivity 2.2 dBi, 0 dBd.

- 1/2 Wave
  - A single radiating element 1/2 wavelength long
  - Directivity 3.8 dBi, 1.6 dBd

- 5/8 Wave
  - A single radiating element 5/8 wavelength long
  - Directivity 5.2 dBi, 3.0 dBd.

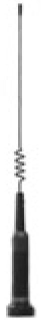
- Collinear
  - Two or three radiating elements separated by phasing coils for increased gain. Four styles are common:
    - 5/8 over 1/4: top element is 5/8 wave and bottom element is 1/4 wave. Directivity 5.4 dBi, 3.2 dBd.
    - 5/8 over 1/2: top element is 5/8 wave and the bottom is 1/2 wave. Directivity 5.6 dBi, 3.4 dBd.
    - 5/8 over 5/8 over 1/4: the top 2 elements are 5/8 wave and the bottom element is 1/4 wave. Directivity 7.2 dBi, 5.0 dBd.
    - 5/8 over 5/8 over 1/2: the top 2 elements are 5/8 wave and the bottom element is 1/2 wave. Directivity 7.6 dBi, 5.4 dBd.

http://www.larsen-antennas.com/techref_antbasicconcepts.shtml

Example Mobile Antennas

- Larsen NMO2/70
  - GAIN
    - VHF: 3.8 dBi
    - UHF: 5.2 dBi
  - TYPE
    - VHF: center loaded 1/2 wave
    - UHF: collinear

- Diamond NR72BNMO
  - 2m / 70cm
  - ¼ wavelength, ½ wavelength
  - Gain: 2.15dBi / 2.15dBi



Antennas for VHF/UHF

Base Station Operation

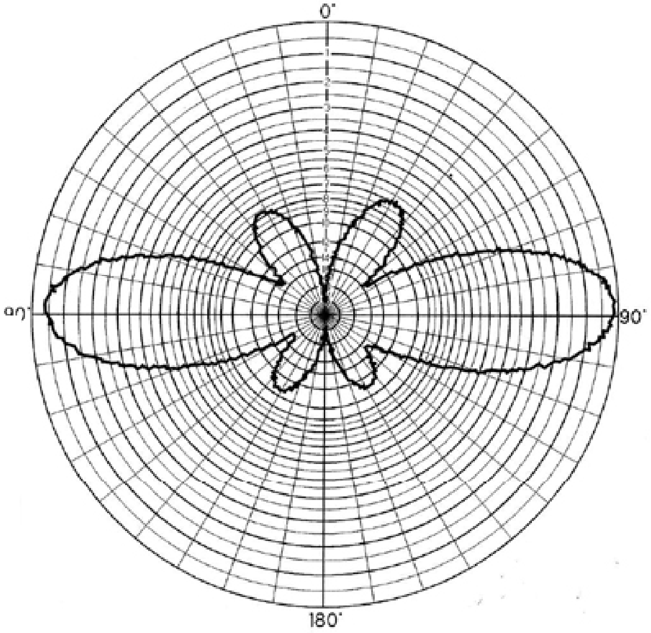
Omnidirectional

- Gain greater than unity is achieved by forming a collinear vertical array, which reduces the elevation beamwidth but leaves the azimuth (horizon) pattern unaffected

Examples

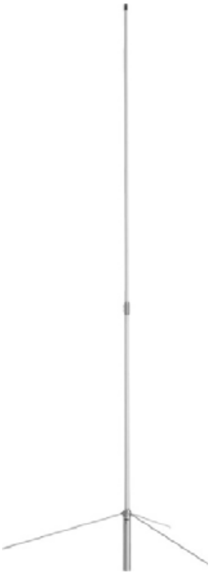
- Diamond CP22E
    - Frequency: 144-148 MHz
    - Gain: 6.5dB
    - Power: 200 watts
    - Connector: UHF
    - Length: 8.9'
    - Wind Rating: 70 mph

Diamond CP22E Radiation Pattern
E-Plane 145 MHz

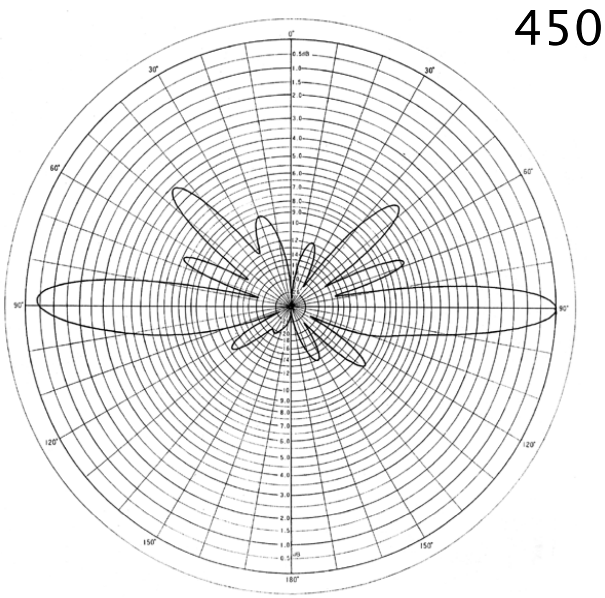


Examples

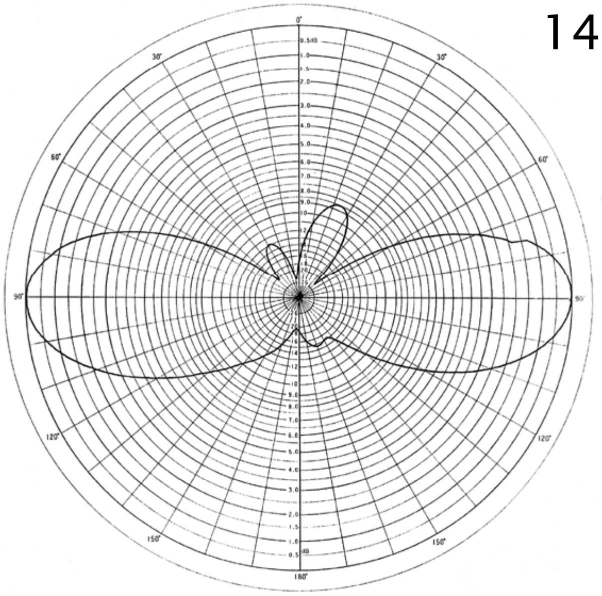
- Diamond X200A
  - Band: 2m/70cm
  - Gain (dB): 6.0/8.0
  - Max Power Rating: 200
  - Wind Rating: 112
  - Height (feet): 8.3
  - Connector: UHF
  - Element Phasing:
    - 2-5/8l, 4-5/8l



450 MHz

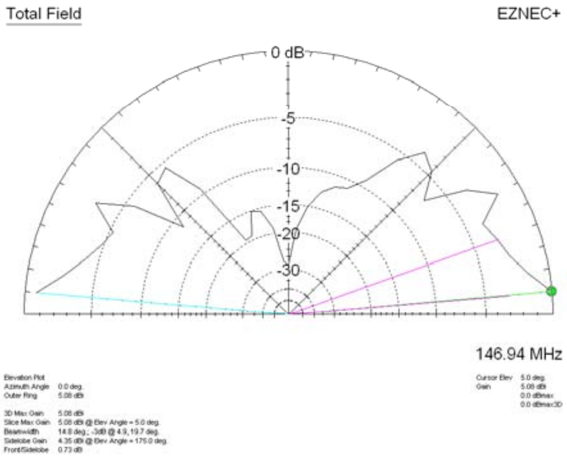


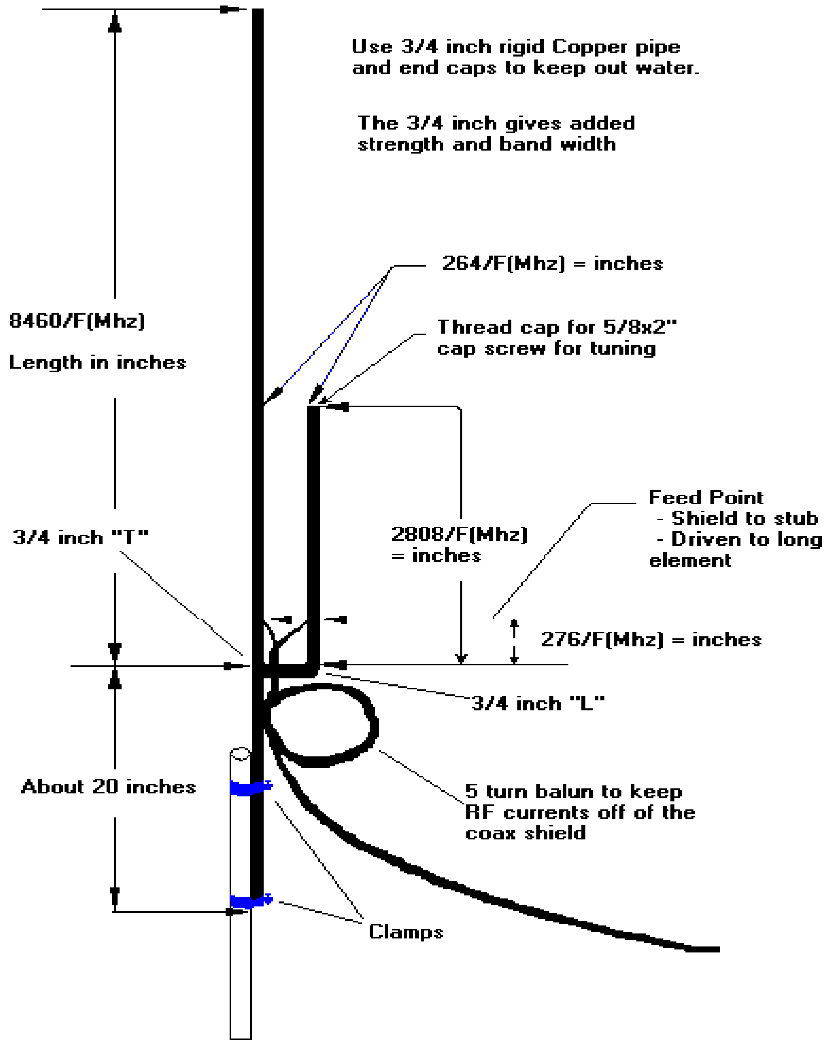
147 MHz



The J-Poll

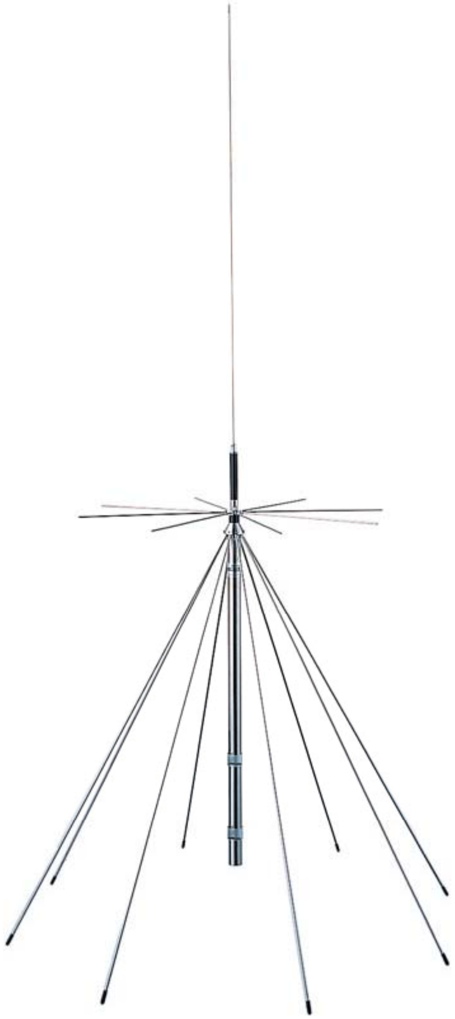
- Can also make a J-Pole out of copper tubing for a more permanent design





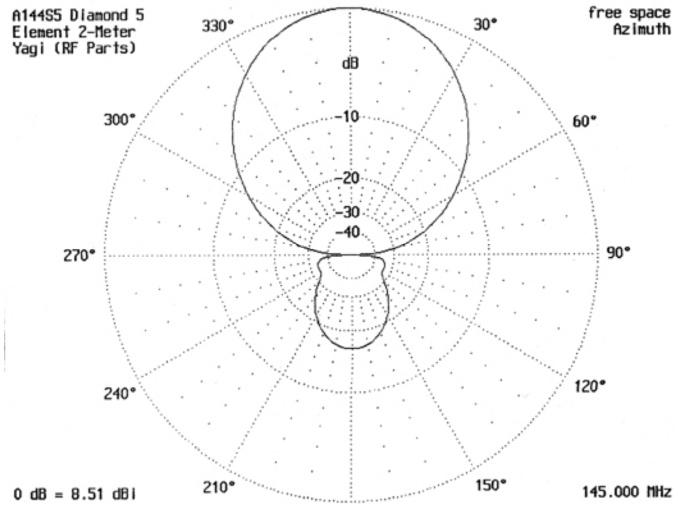
Discone

- Wideband
  - 25 to 1300 MHz receive
  - 50-1300 MHz transmit
- Compact and lightweight design
- Gain around 2dBi



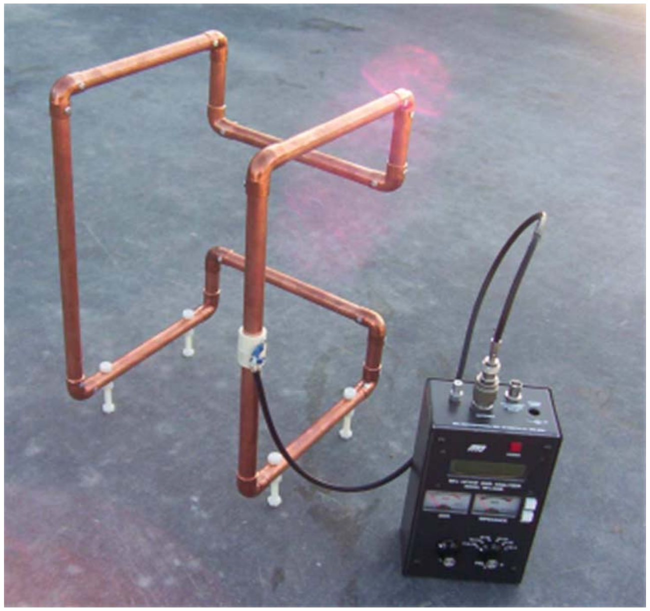
Directional

- Yagi-Uda Beams
- Don’t forget polarization!
- Gain on the order of 9 dBi



“Folded Loop” for 2 and 10 meters

- One-wavelength loop that is reduced in height and width by being folded into three dimensions
  - 28-MHz loop that is normally 9 feet on a side becomes a box-shaped antenna that is 3 by 3 by 5 feet
- Performance that is competitive with a ground plane yet requires only 15 square feet of ground area versus 50 for the ground plane



Dave Cuthbert WX7G; http://download.antennex.com/preview/Jun603/3dfl4.pdf

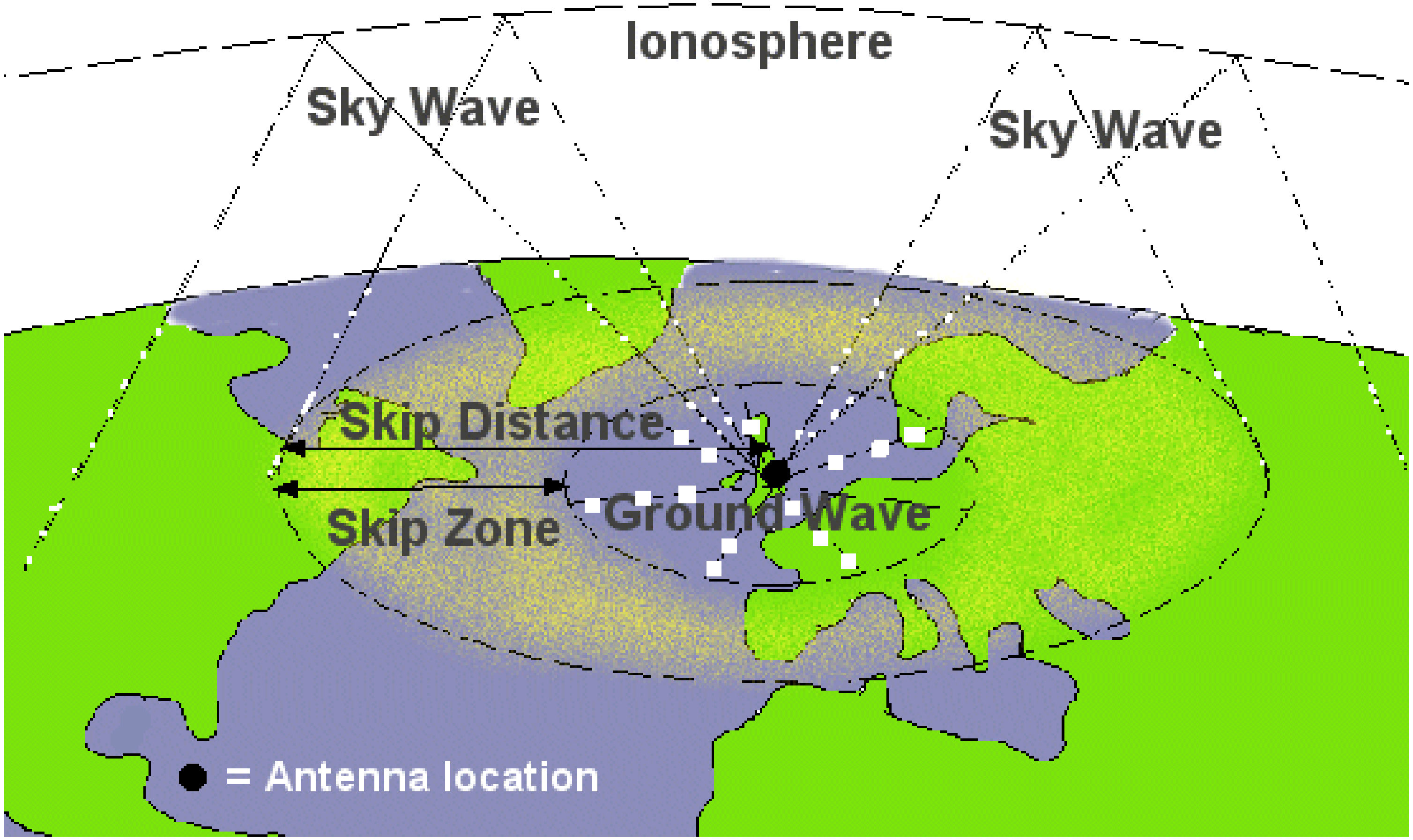
Antennas for HF

Fundamentals

HF Propagation

- Who I want to talk to is close by
  - Ground wave
- Who I want to talk to is really far away (many hundreds to thousands of miles)
  - Skywave
- Who I want to talk to is in between the two
  - In the “skip zone”
  - Near Vertical Incidence Skywave (NVIS)

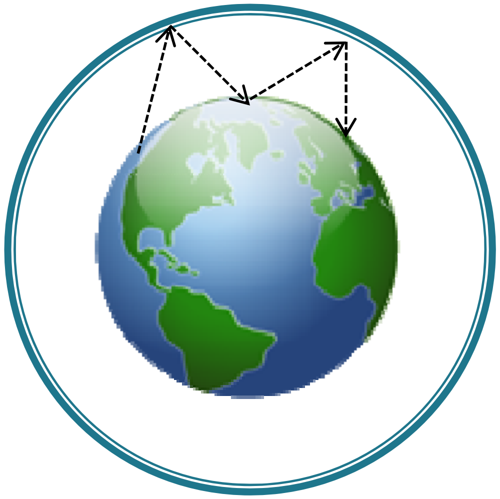
You have to use a different antenna for each of these


Ionosphere
Sky Wave
Sky Wave
Skip Distance
Skip Zone
Ground Wave
● = Antenna location

Rule of Thumb for HF …

- There is no good rule of thumb for HF …
- No single perfect antenna for HF operation
  - Depends on:
    - Size and terrain of the area you need to cover
    - Conditions under which you must install/use it

Take off Angle is Everything!

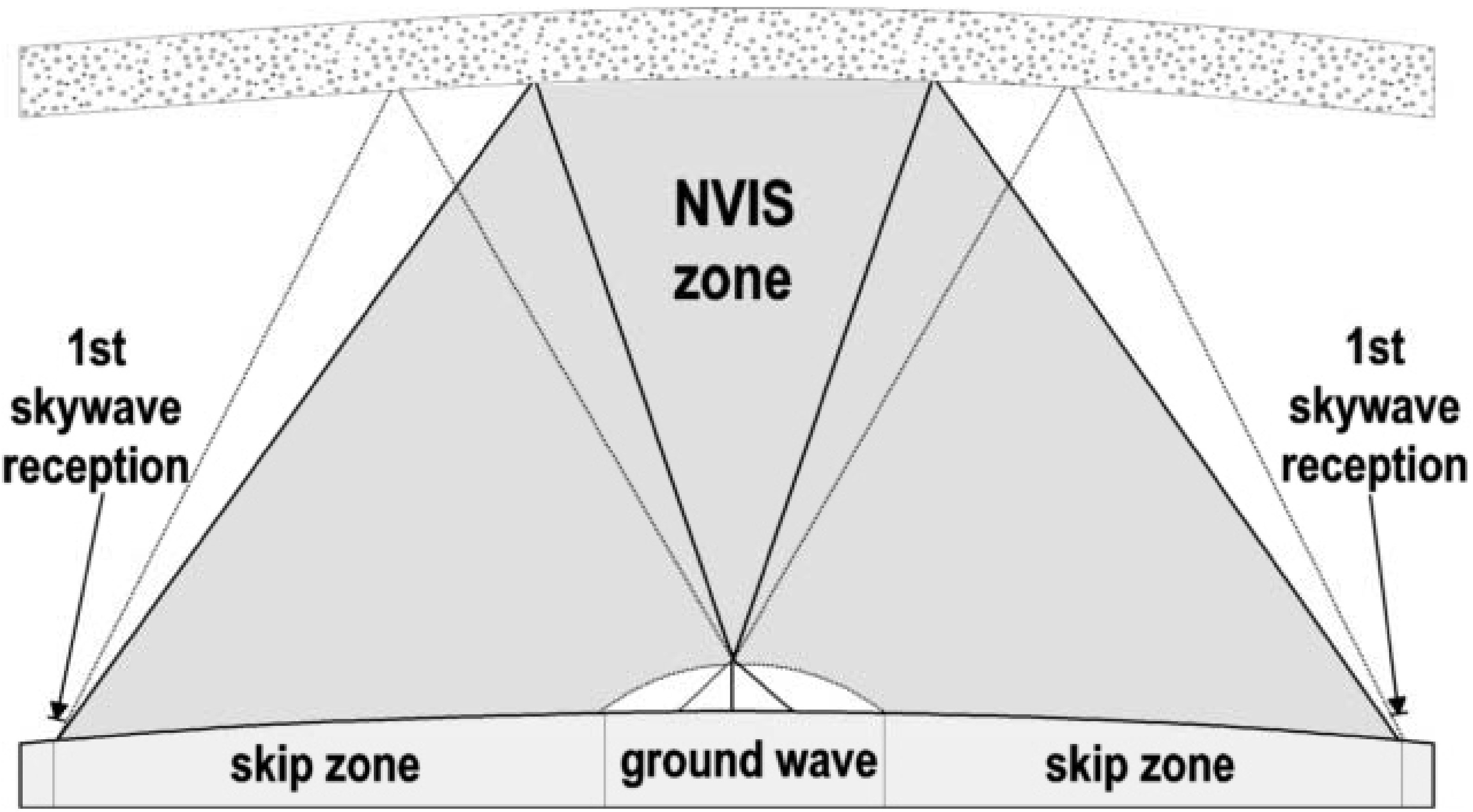


HF Antenna Choice

- Verticals have low takeoff angles
    - They have almost no radiation straight up
    - Great for DX, but bad for regional coverage
    - OK for “ground wave” region

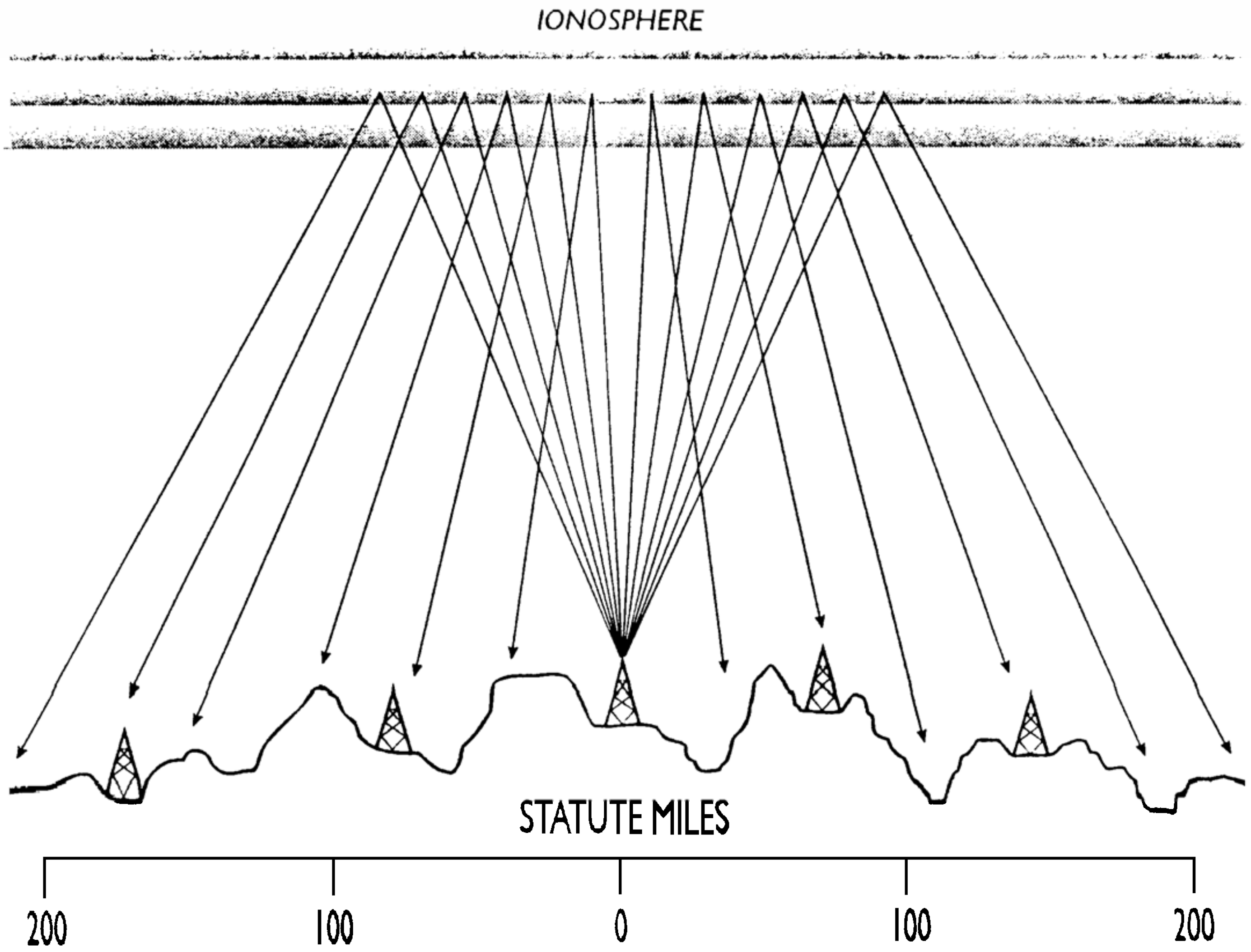
- Horizontal antennas (dipoles, beams) at relatively high distances above the ground are good for long distance

- Horizontal antennas can radiate high angles (“NVIS”) if put at an appropriate low height over ground

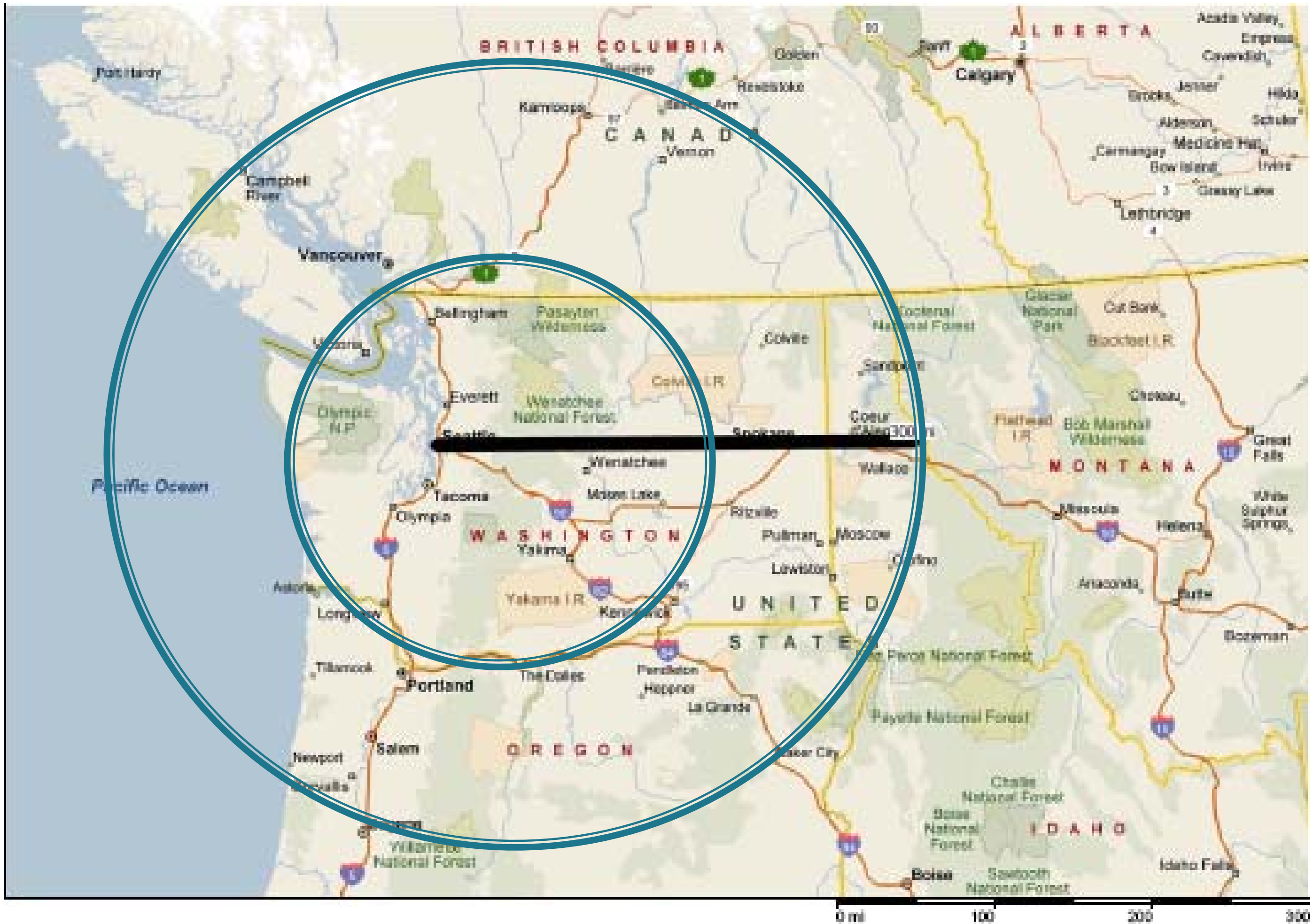

NVIS zone
1st skywave reception
1st skywave reception
skip zone
ground wave
skip zone

NVIS

- “Near Vertical Incidence Skywave" (NVIS)
  - For local operations up to a few hundred miles
  - Random wire or dipole hung at a less than ¼ wavelength above the ground
  - Signal is reflected almost straight up, bounces off the ionosphere directly back downward
  - Best on 40 meters during the day, switching to 80 meters around sunset


IONOSPHERE
STATUTE MILES

150 and 300 miles from Seattle



opyright © and (P) 1988–2007 Microsoft Corporation and/or its suppliers. All rights reserved. http://www.microsoft.com/streets/
ertain mapping and direction data © 2007 NAVTEQ. All rights reserved. The Data for areas of Canada includes information taken with permission from Canadian authorities, including: © Her Majesty the Queen in Right of Canada, © Queen's Printer for
ntario. NAVTEQ and NAVTEQ ON BOARD are trademarks of NAVTEQ. © 2007 Tele Atlas North America, Inc. All rights reserved. Tele Atlas and Tele Atlas North America are trademarks of Tele Atlas, Inc.

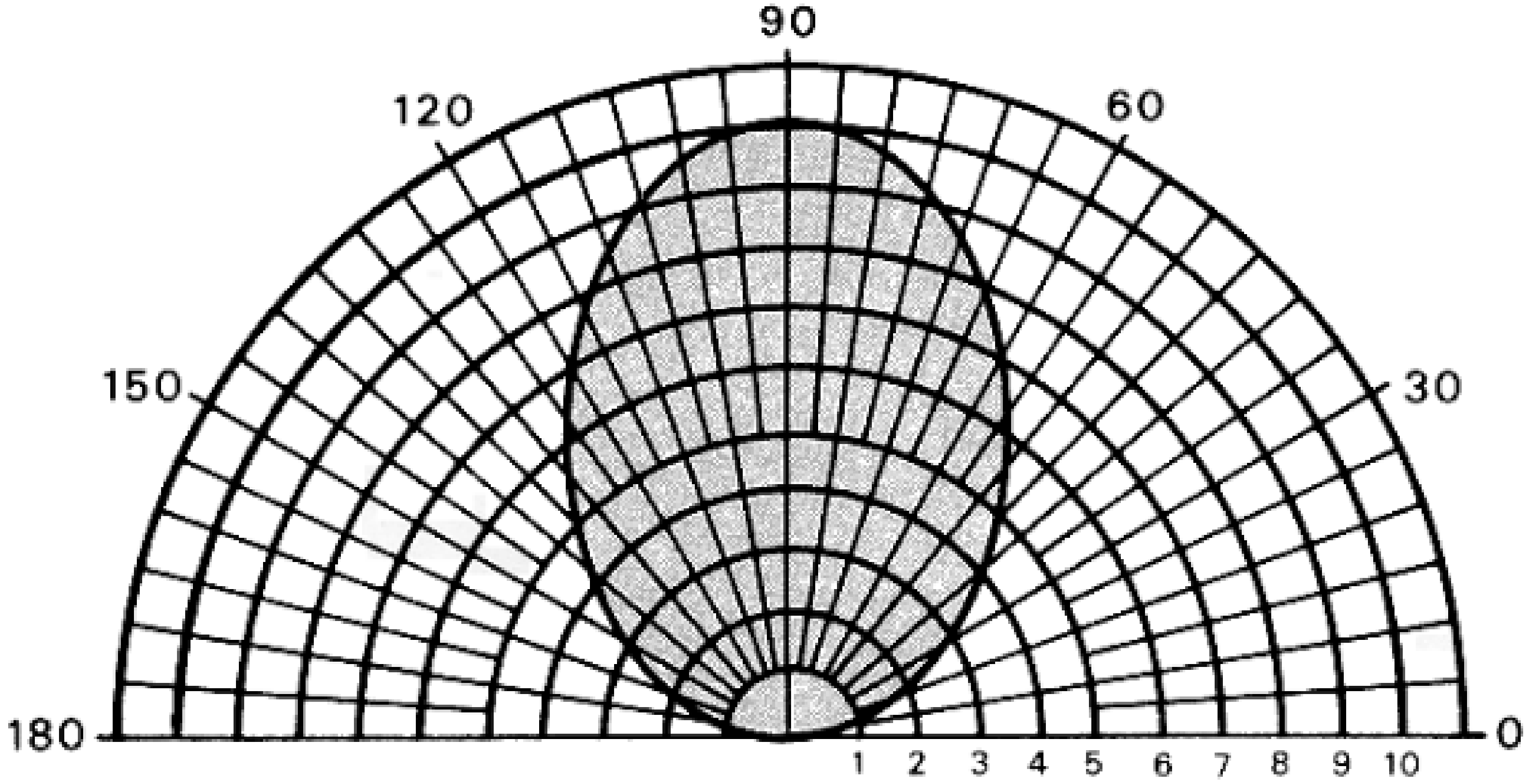
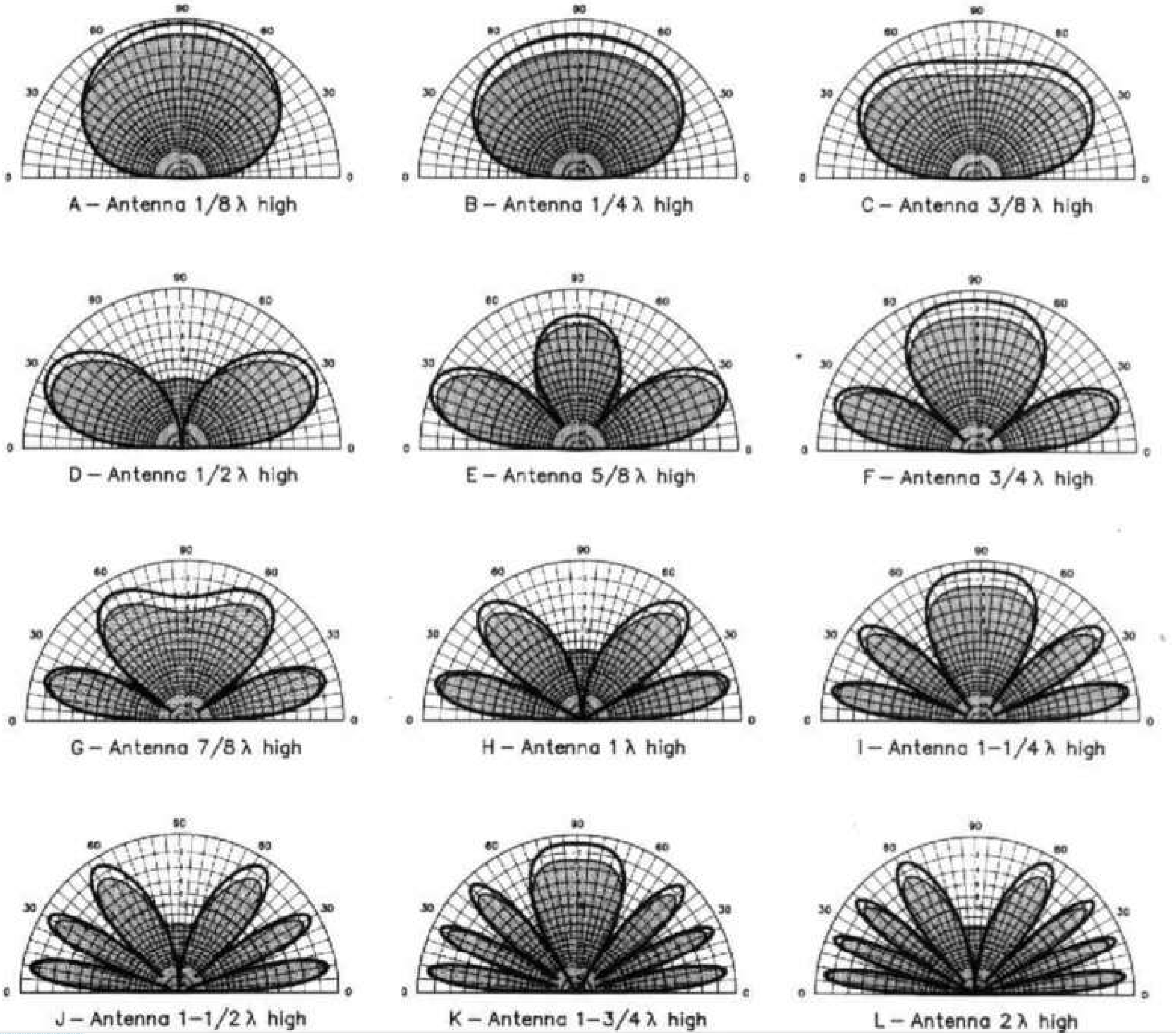


Figure M-6 Typical elevation plane patterns for half-wavelength antennas one-eighth wavelength or less above ground.

Height Affects Antenna Pattern



A – Antenna 1/8 λ high

B – Antenna 1/4 λ high

C – Antenna 3/8 λ high

D – Antenna 1/2 λ high

E – Antenna 5/8 λ high

F – Antenna 3/4 λ high

G – Antenna 7/8 λ high

H – Antenna 1 λ high

I – Antenna 1-1/4 λ high

J – Antenna 1-1/2 λ high

K – Antenna 1-3/4 λ high

L – Antenna 2 λ high

Source: http://www.moonraker.com.au

NVIS Design Principles

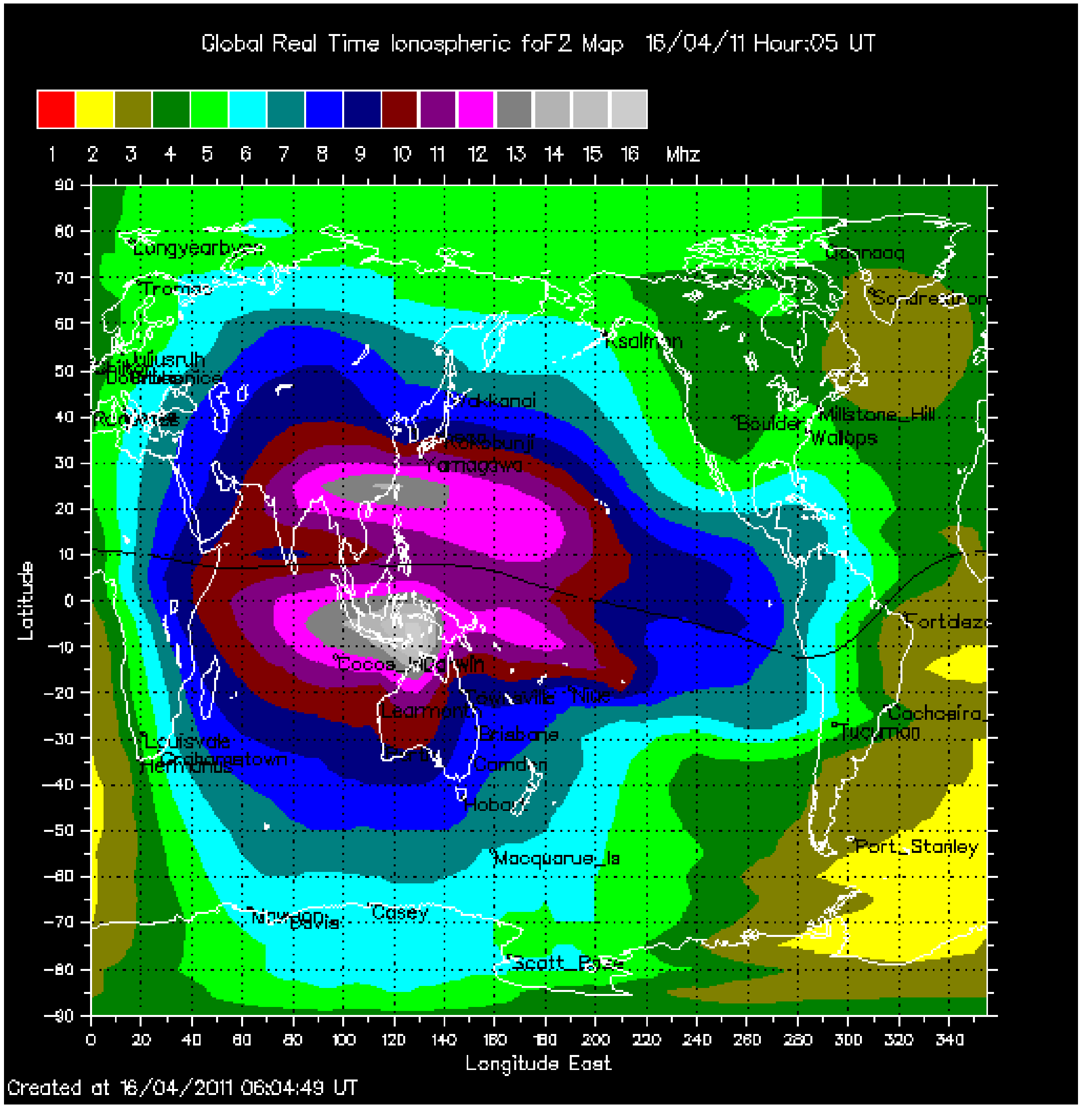
- One of the most effective antennas for NVIS is a dipole positioned from .1 to .25 wavelengths (or lower) above ground
- Heights of 5 to 10 feet above ground are not unusual for NVIS setups
- The inverted-V is another good NVIS antenna so long as the apex angle is kept gentle--about 120 degrees or greater
- Power not critical – 25 watts up to 100 watts
- Antenna design not as critical
  - Random wires with a tuner work
  - Dipoles

NVIS Frequencies …

- foF2 (“critical frequency”) is the highest frequency at which a signal sent straight up is reflected back down

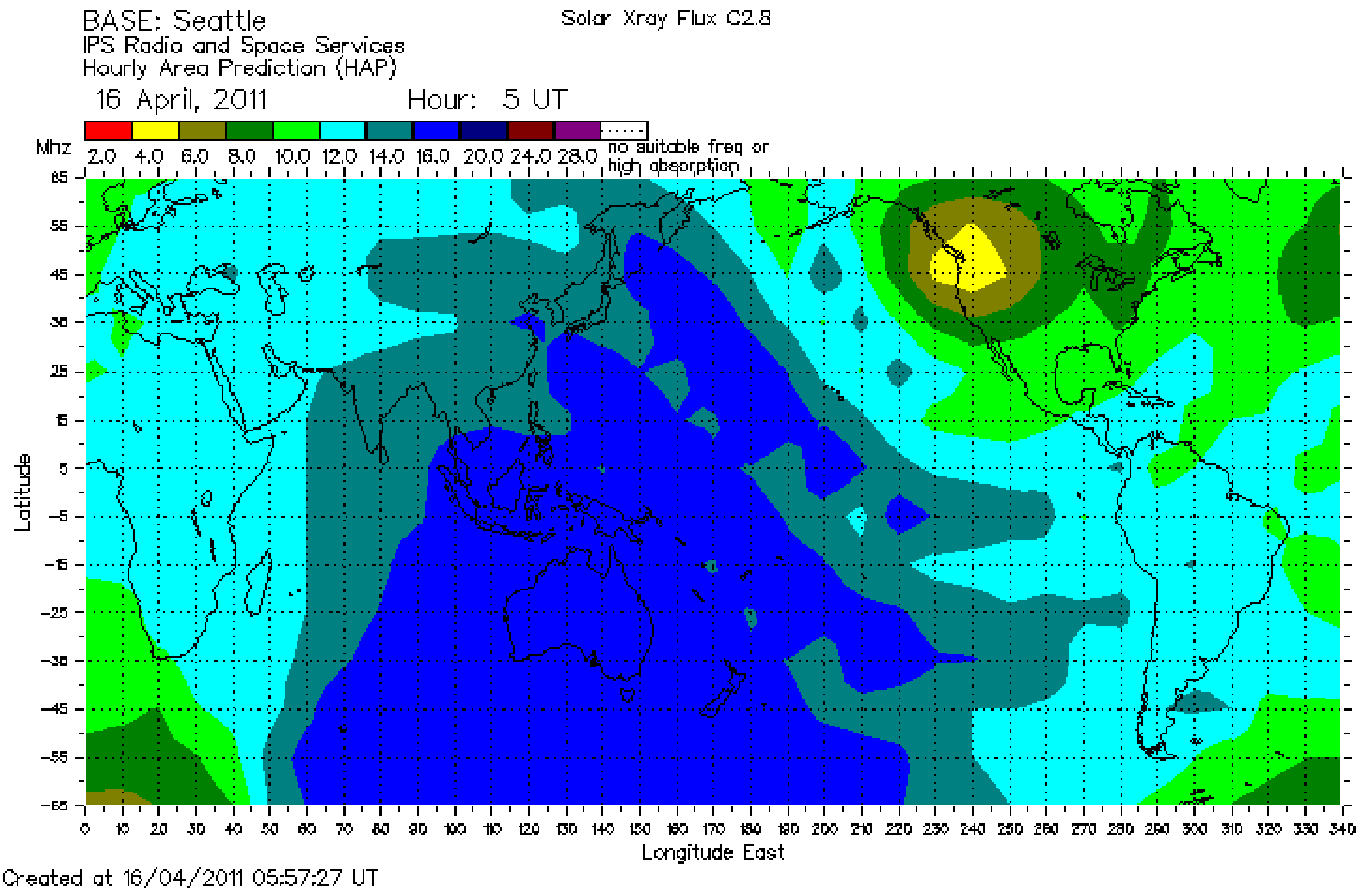
- Between 2.0 and 10 MHz
  - 40m amateur band for daytime
  - 75/80m for nighttime communications
  - 60m band with it’s power & antenna limitations can be very effective using NVIS techniques

- Australian Space Weather Agency
  - http://www.ips.gov.au
  - Global HF Ionospheric Map

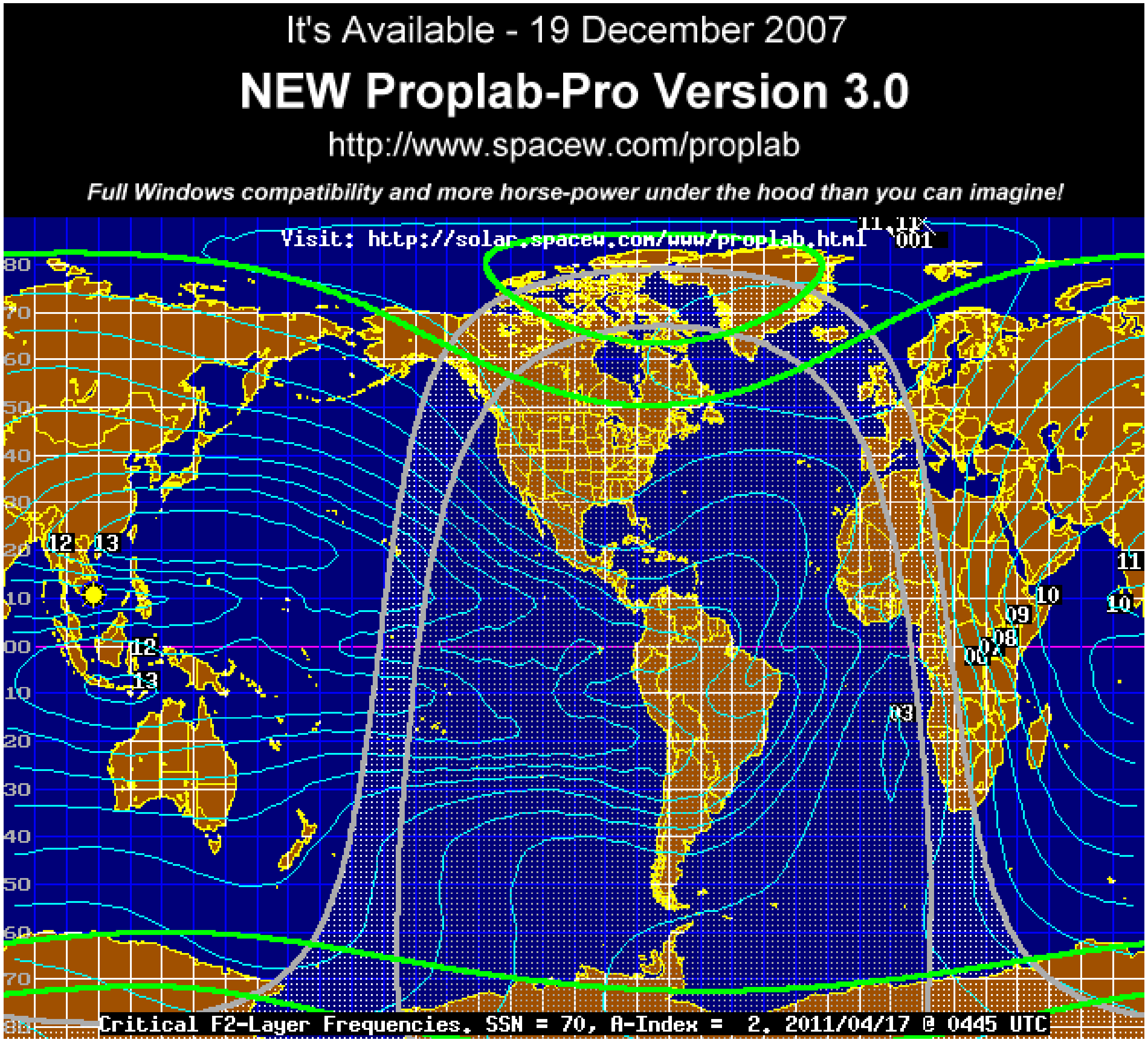


The above map can be used as a guide to NVIS ionospheric frequency support.
The highest (see note) frequency which the ionosphere will reflect vertically is called foF2

Hourly Area Predictions (HAP) of communication frequencies based on the previous hours observed conditions for the Global HF ionosphere



The HAP chart is a guide to frequency selection for HF communications between mobiles and a specified base station, in this case Seattle.



It's Available - 19 December 2007

NEW Proplab-Pro Version 3.0

http://www.spacew.com/proplab

Full Windows compatibility and more horse-power under the hood than you can imagine!

Visit: http://solar.spacew.com/www/proplab.html

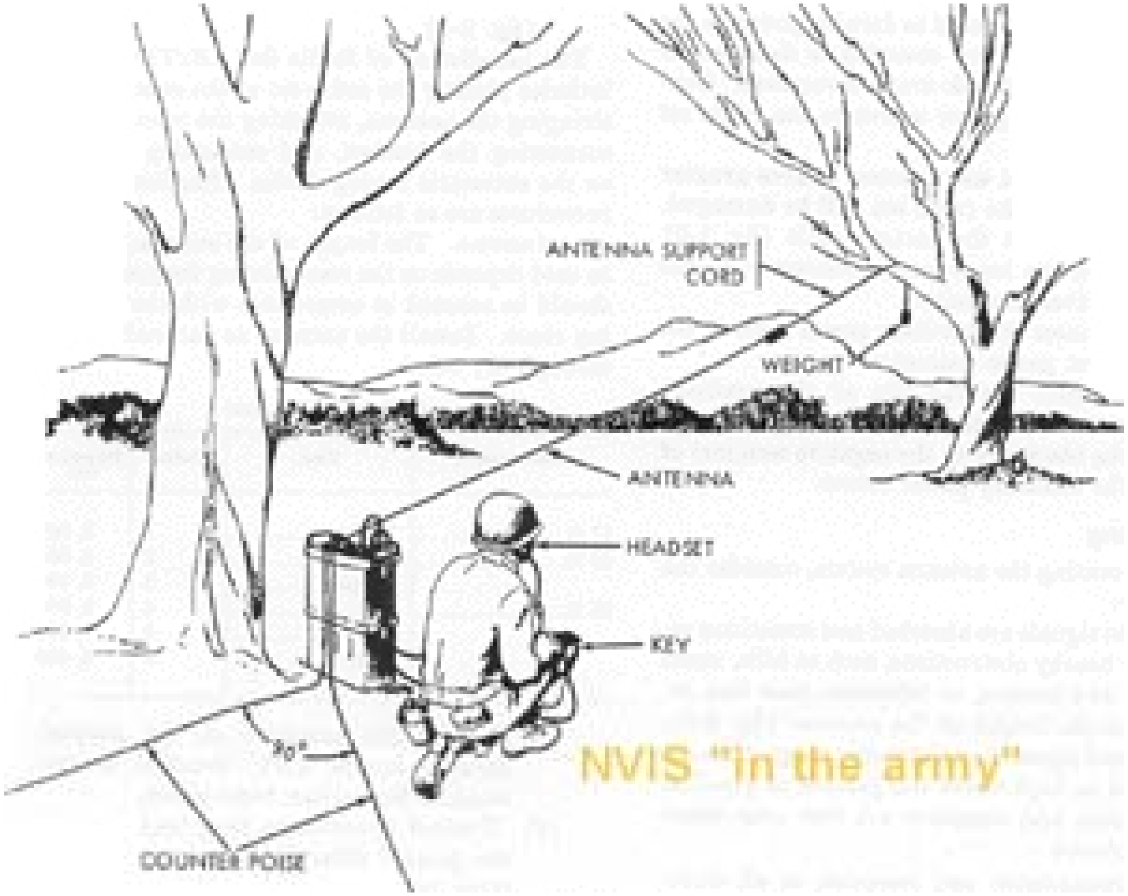
Critical F2-Layer Frequencies, SSN = 70, A-Index = 2, 2011/04/17 @ 0445 UTC

http://www.spacew.com/www/fof2.html

Antennas for HF

“Manpack” Operation

Long wire antenna …

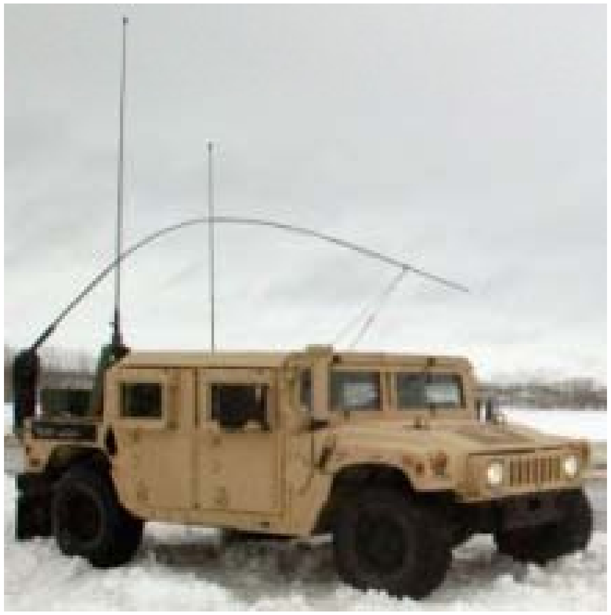


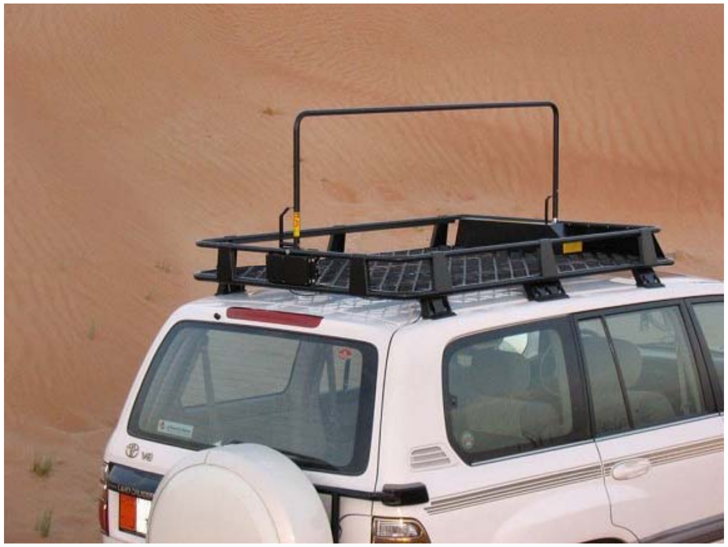
Antennas for HF

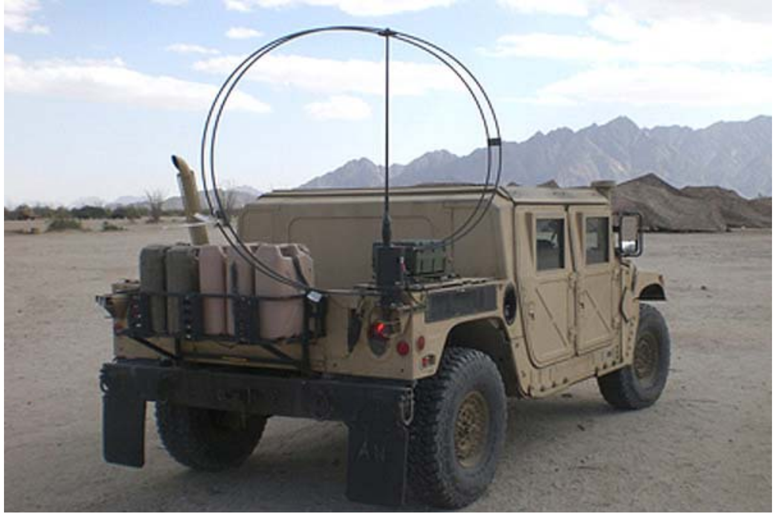
Mobile Operation

Mobile NVIS

Tilted whip and Loops







Mobile NVIS – Which way to tilt the antenna?

- Mobile Whip Antenna
- 4.8m whip antenna was mounted at the rear corner of the vehicle roof, was tilted forward and backwards along its longest dimension
- Best performance is seen with the whip tilted backwards away from the vehicle at a substantial angle
- At tilt angles less than 50 degrees from the vertical the performance remains similar to that of the vertical whip

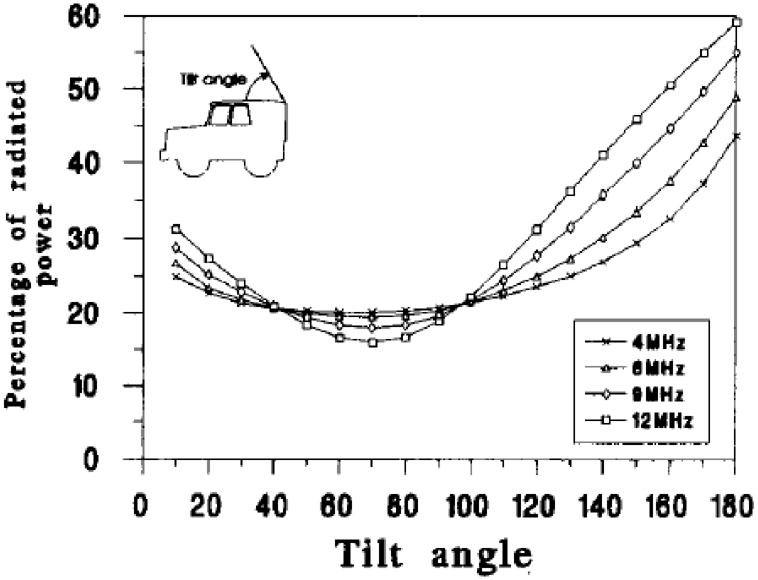
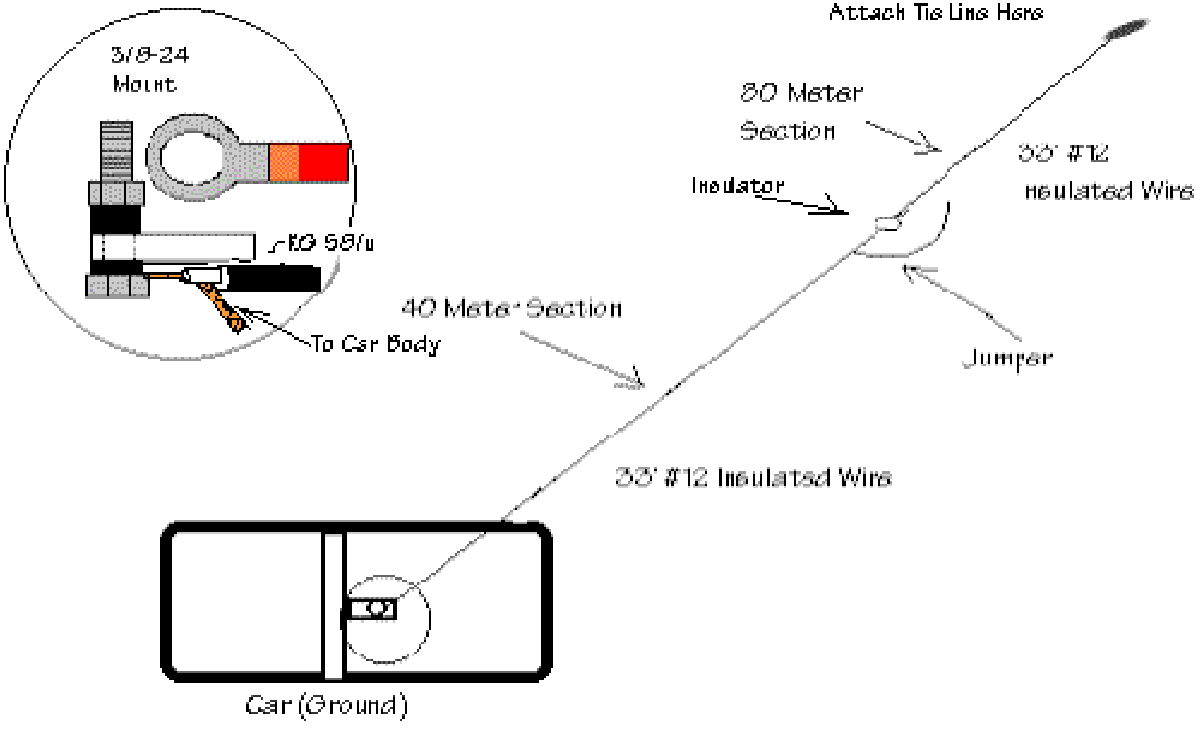


Figure 3 Variation of the percentage of radiated power in θ<45° with tilt angle.

NOVEL ANTENNA CONFIGURATIONS FOR VEHICLE-BORNE NVIS APPLICATIONS
K.P.Murray and B.A.Austin, University of Liverpool, UK
IEE Antennas and Propagation, 4-7 April 1995, Conference Publication No. 40

NVIS Roadside Antenna



NVIS Roadside Antenna

Drawing by ***W7ARC***

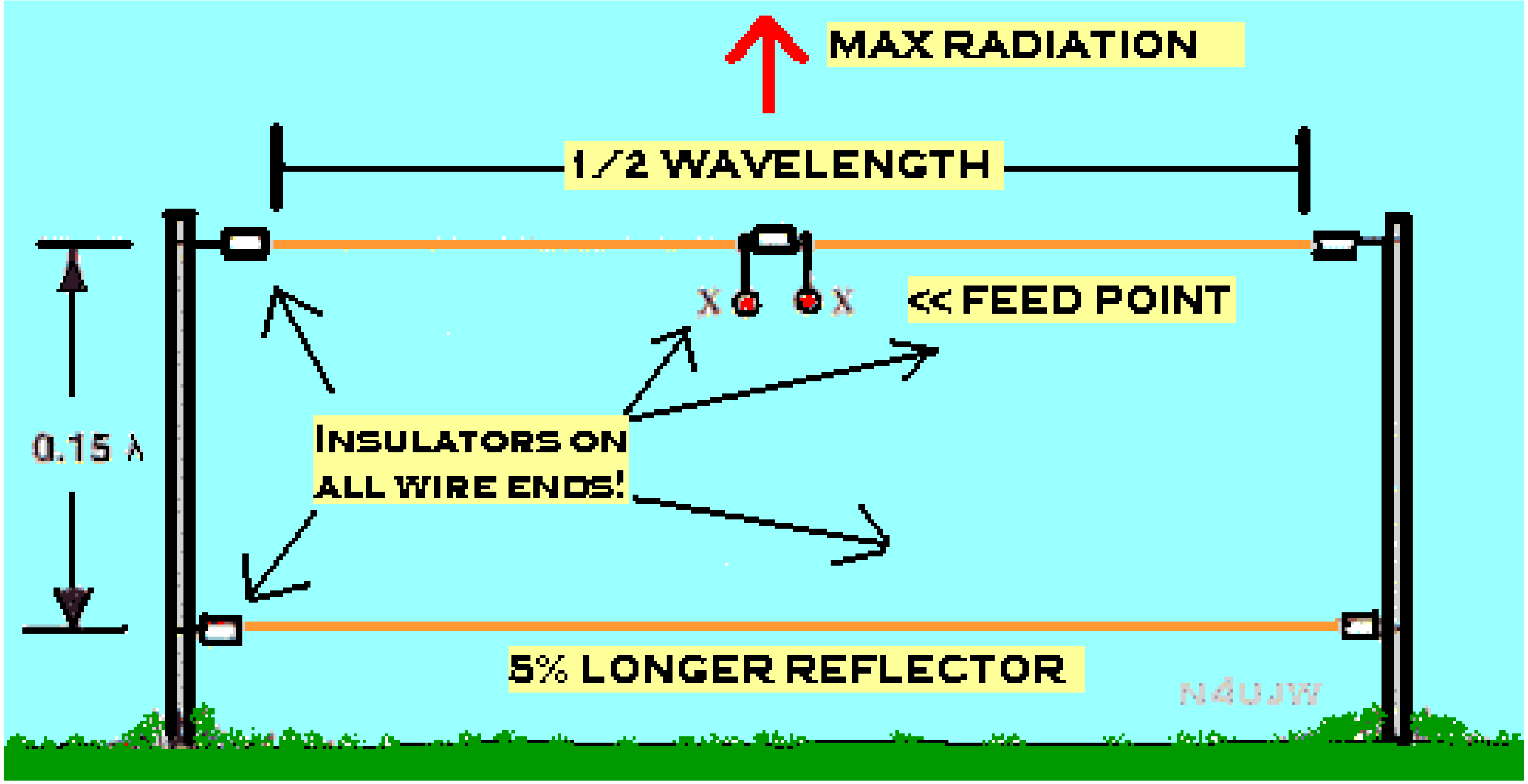
Non-NVIS Mobile

- Many commercial antennas available
  - Outbacker
  - Tarheel Antennas
  - Lakeview monoband whips

Antennas for HF

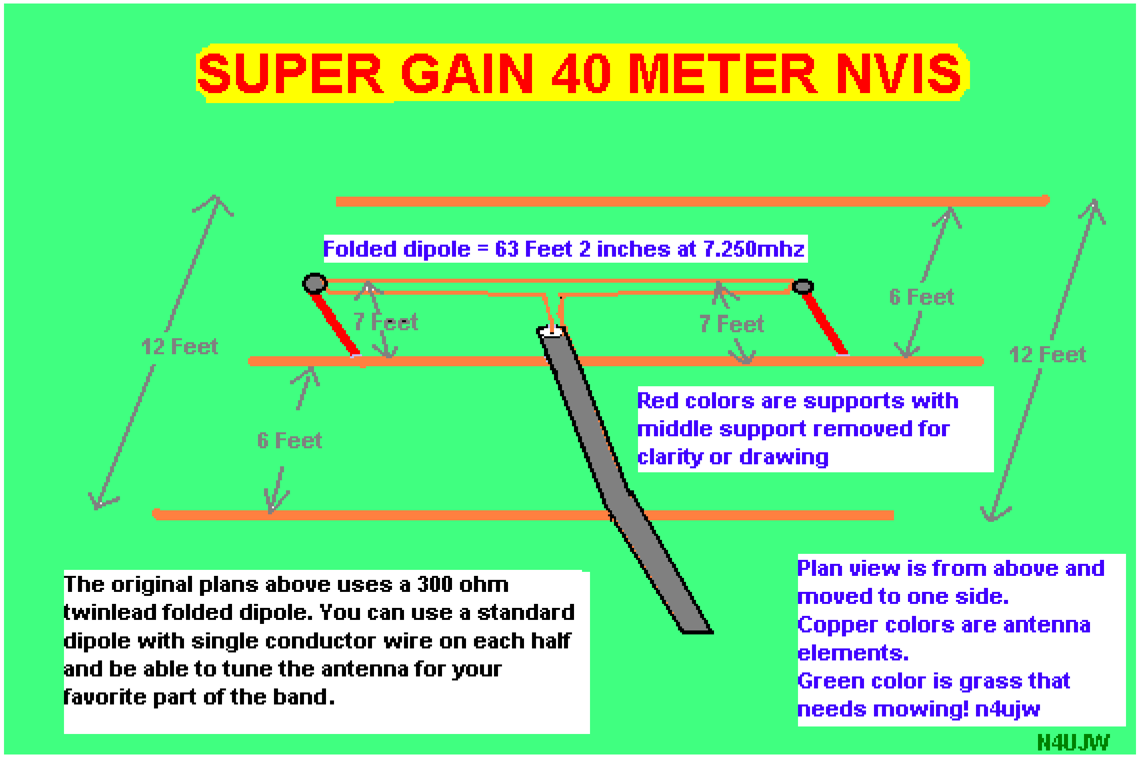
Field & Permanent NVIS Designs

Cloudwarmer NVIS



http://www.hamuniverse.com/nvisbeam.html

“Super Gain NVIS”



SUPER GAIN 40 METER NVIS

Folded dipole = 63 Feet 2 inches at 7.250mhz

Red colors are supports with middle support removed for clarity or drawing

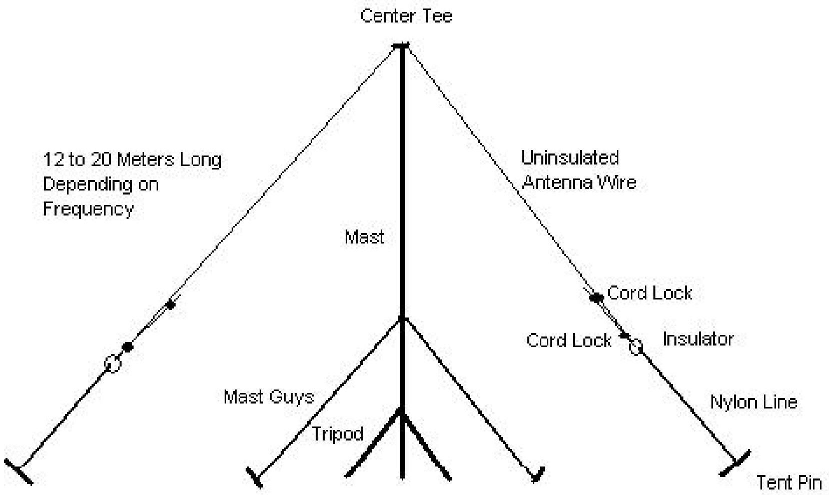
The original plans above uses a 300 ohm twinlead folded dipole. You can use a standard dipole with single conductor wire on each half and be able to tune the antenna for your favorite part of the band.

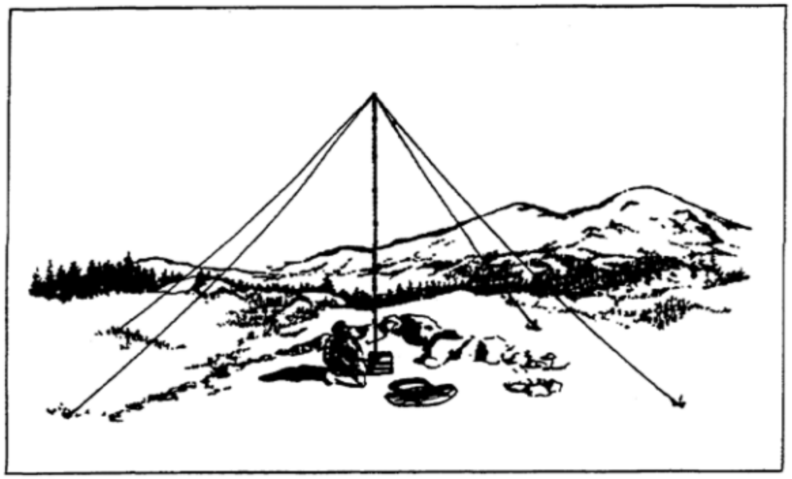
Plan view is from above and moved to one side.
Copper colors are antenna elements.
Green color is grass that needs mowing! n4ujw

- 73 Magazine, October 1969, Ed Dusina, W4NVK, Melbourne, Fl
- http://www.hamuniverse.com/supernvis.html

Other NVIS Designs

Buddipole N-Vee NVIS Antenna for 80/75/60 Meter Bands





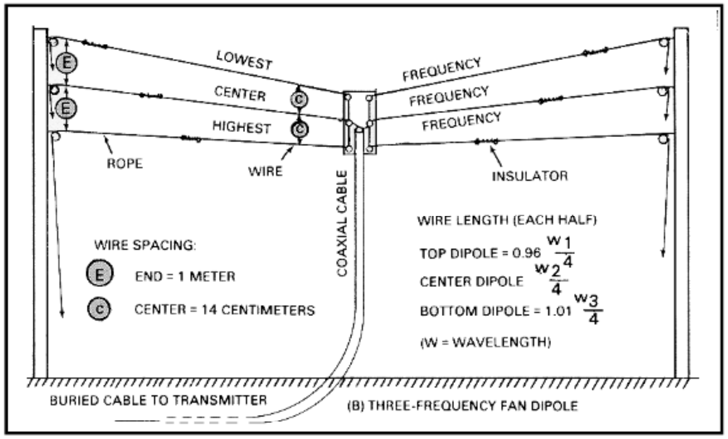
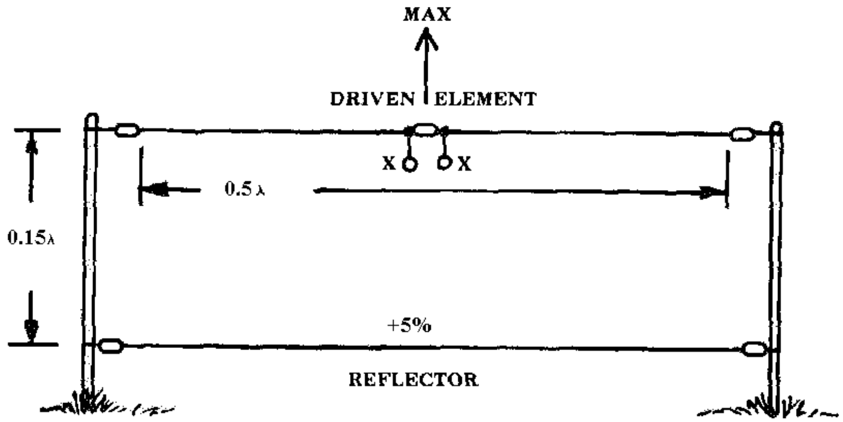

LOWEST
FREQUENCY
CENTER
FREQUENCY
HIGHEST
FREQUENCY
E
E
C
C
ROPE
WIRE
INSULATOR
COAXIAL CABLE
WIRE SPACING:
E END = 1 METER
C CENTER = 14 CENTIMETERS
WIRE LENGTH (EACH HALF)
TOP DIPOLE = 0.96 $\frac{W_1}{4}$
CENTER DIPOLE $\frac{W_2}{4}$
BOTTOM DIPOLE = 1.01 $\frac{W_3}{4}$
(W = WAVELENGTH)
BURIED CABLE TO TRANSMITTER
(B) THREE-FREQUENCY FAN DIPOLE

Figure M-8. Fan dipole NVIS base station antenna.

NVIS Designs



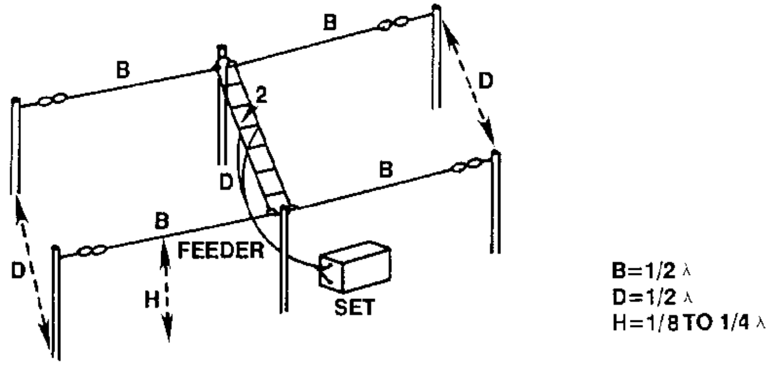


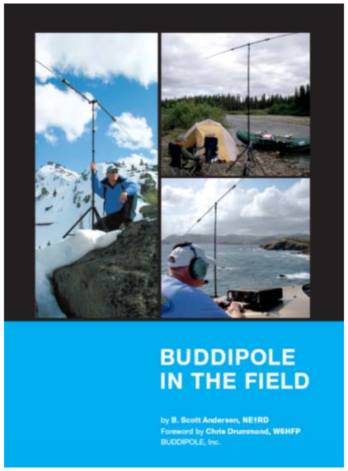
Figure 6. Jamaica antenna (Can be built from standard antenna kits AN/GRA-50; has four times the gain of the dipole antenna.)

Double Bazooka NVIS

- DOUBLE BAZOOKA antenna is an extremely broad banded Half Wave Antenna which can operate efficiently across an entire Ham band with little change to the SWR
- Used effectively as an NVIS antenna when installed near the ground (15-20 feet)

Buddipole & Buddistick

http://www.buddipole.com/documentation.html



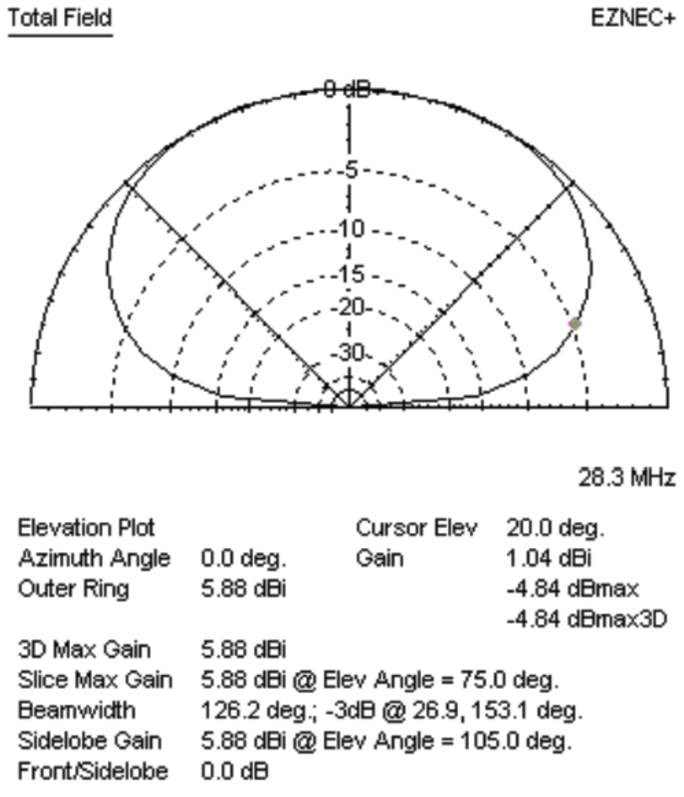
BUDDIPOLE
IN THE FIELD

by B. Scott Andersen, NE1RD
Foreword by Chris Drummond, W6HFP
BUDDIPOLE, Inc.

Buddipole NVIS "Quick Fix"

- http://lib.store.yahoo.net/lib/buddipole/nvis2008.pdf

Buddipole NVIS

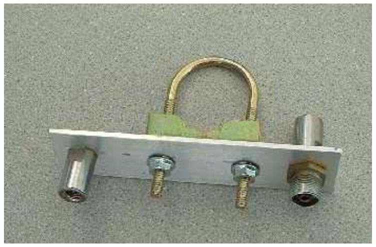


```
Elevation Plot                      Cursor Elev    20.0 deg.
Azimuth Angle     0.0 deg.          Gain           1.04 dBi
Outer Ring        5.88 dBi                         -4.84 dBmax
                                                   -4.84 dBmax3D
3D Max Gain       5.88 dBi
Slice Max Gain    5.88 dBi @ Elev Angle = 75.0 deg.
Beamwidth         126.2 deg.; -3dB @ 26.9, 153.1 deg.
Sidelobe Gain     5.88 dBi @ Elev Angle = 105.0 deg.
Front/Sidelobe    0.0 dB
```

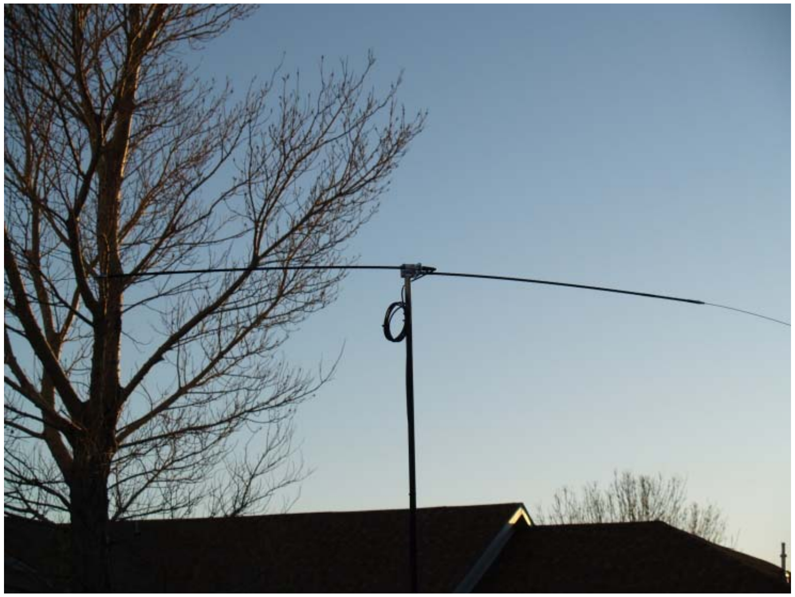
Figure 11 Elevation plot for a *Buddipole* on 10m at 8 feet

Hamstick Dipole

- Hamstick antennas for 40 or 75m



- Hamstick dipole mount



- NVIS – keep low to the ground

What works best?

- The differences in performance between various antenna configurations seem to fall into the following approximate rankings (best performance to least efficient):
  - Full wave length loop (not practical for most of us)
  - Half wave length dipole with the feed point lower than the ends yet about fifteen foot height.
  - Half wave dipole – inverted V configuration (approximately -4.5db below the "saggy" dipole above!)
  - Random length wire
    - LDG 4:1 balun feeding 112 feet of number 14 wire with an average height of ten feet works quite well
  - "Dual Ham-stick" dipole
    - does well under ARES/RACES operating conditions
  - Antenna below 4 feet high

Pat Lambert – W0IPL; http://www.w0ipl.net/ECom/NVIS/nvis.htm

Previous Comm Academy

- www.commacademy.org
- 2003, NVIS Presentation
  - Tom Sanders, W6QJI & Ed Bruette, N7NVP

Antennas for HF

Long Distance Communication

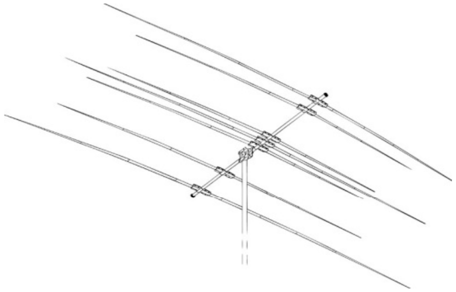
Communications Beyond the Skip Zone

- Another class in itself

- Vertical antennas
  - No ability to reject interfering signals from other directions
  - Vertical antennas shorter than a half wavelength need a ground system

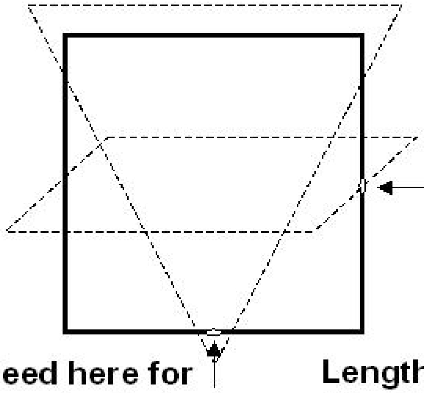
- Wire antennas
  - Dipoles
  - Multiband designs
  - G5RV type
  - End fed half wave
  - End fed Zep

- Directional (beam) antennas
  - Best performance for very wide area nets on 10 to 20 meters
  - Maximize desired signals and reduce interference from stations in other directions
  - Expensive, large, and difficult to store and transport



FULL-WAVELENGTH LOOP

Can be any shape, horizontal or
vertical - feed with coax and 2:1 balun

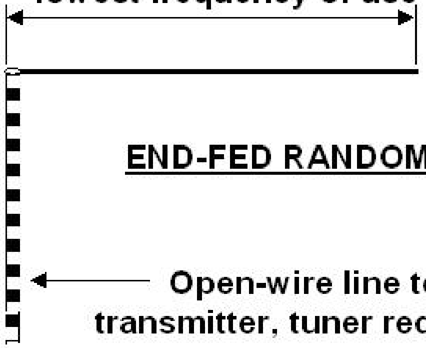


Feed here for
vertical
polarization

Feed here for
horizontal polarization

Length = 1005/f
(f in MHz, L in feet)

At least 1/4-wavelength at
lowest frequency of use

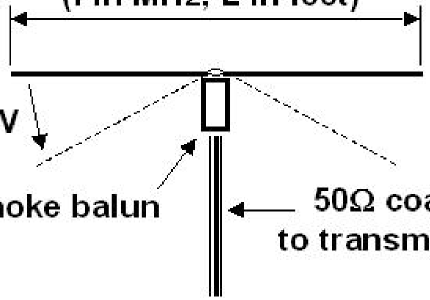


END-FED RANDOM WIRE

Open-wire line to
transmitter, tuner required

HALF-WAVE DIPOLE

Length = 468/f
(f in MHz, L in feet)



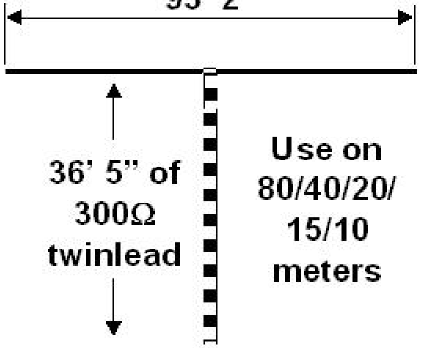
Inverted-V

Choke balun

50Ω coax
to transmitter

G5RV DIPOLE by ZR1DQ

93' 2"

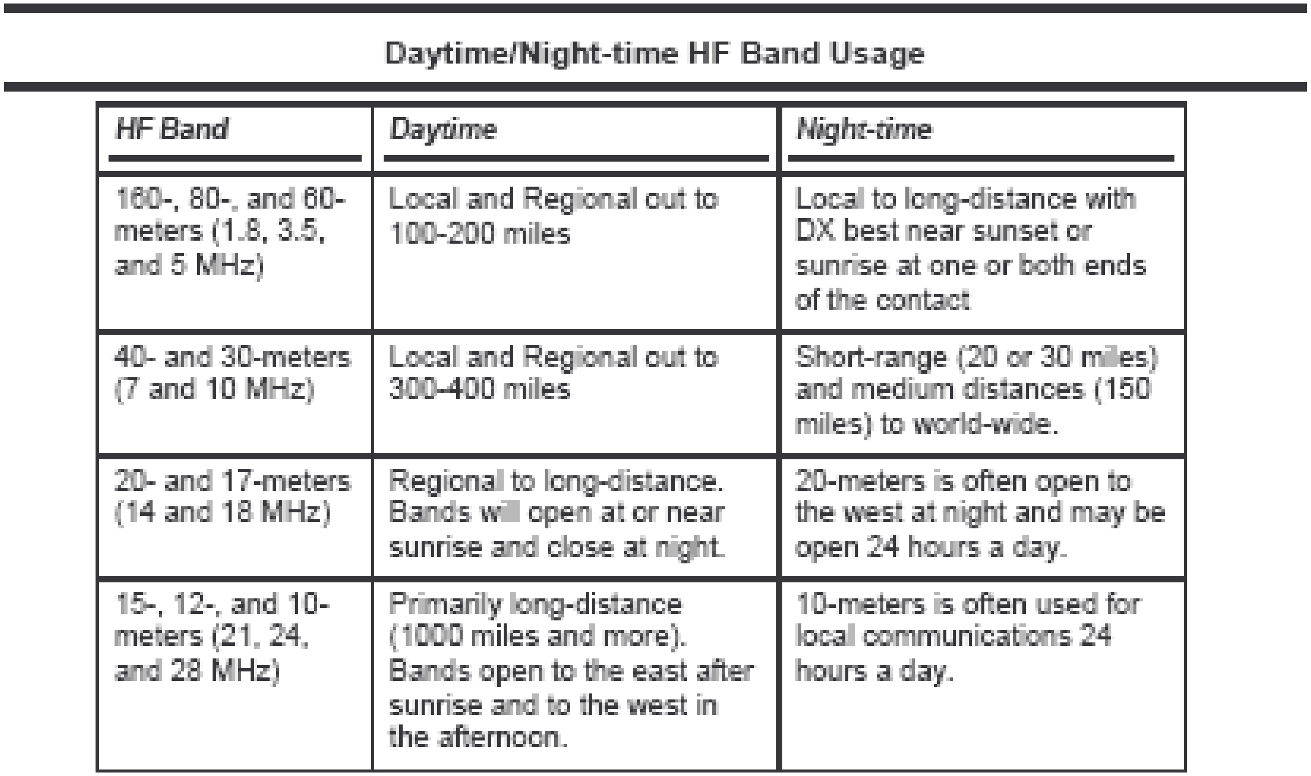


36' 5" of
300Ω
twinlead

Use on
80/40/20/
15/10
meters

Connect to 50Ω
coax, no balun
required

Band Rules of Thumb



Daytime/Night-time HF Band Usage

HF Band	*Daytime*	*Night-time*
160-, 80-, and 60-meters (1.8, 3.5, and 5 MHz)	Local and Regional out to 100-200 miles	Local to long-distance with DX best near sunset or sunrise at one or both ends of the contact
40- and 30-meters (7 and 10 MHz)	Local and Regional out to 300-400 miles	Short-range (20 or 30 miles) and medium distances (150 miles) to world-wide.
20- and 17-meters (14 and 18 MHz)	Regional to long-distance. Bands will open at or near sunrise and close at night.	20-meters is often open to the west at night and may be open 24 hours a day.
15-, 12-, and 10-meters (21, 24, and 28 MHz)	Primarily long-distance (1000 miles and more). Bands open to the east after sunrise and to the west in the afternoon.	10-meters is often used for local communications 24 hours a day.

HF 101 Reference Handout, Ward Silver N0AX, Comm Academy 2004
www.commacademy.org

Getting the Most Out of Your Antenna

Matching

- Transmitter wants to see 50 ohms
- Antenna may not be exactly 50 ohms
  - Mismatch means you have a high SWR, or in other words, your power is not being radiated from the antenna effectively
- Antenna “tuner” is used to make your antenna look like 50 ohms to your transmitter
  - Antenna does not really “tune” – it is an impedance matching device
- Antenna tuner is necessary for most portable wire antennas
- Especially for NVIS antennas
  - Antenna's impedance varies with height above ground and proximity to nearby objects
  - Can be a real problem with expedient installations
- SWR is not a measure of how well an antenna radiates
  - I can build a dummy load with a 1:1 SWR

Don’t Forget the Transmission Line

- Transmission lines have losses
  - Usually rated as dB per 100 ft with an SWR of 1:1
  - The losses are much higher at high SWRs
- Reducing Loss
  - Place the antenna tuner as close to the antenna as possible (lowest loss)
  - Use balanced line between the tuner and the antenna
  - Use low loss coax to feed the antenna (LMR-400 or 9913)

More Reading …

- HF Antennas 101
  - Van Field, W2OQI; QST, September 2004
- The ARRL Antenna Book
- Balanis, “Antenna Theory: Analysis and Design”, Wiley

Questions?